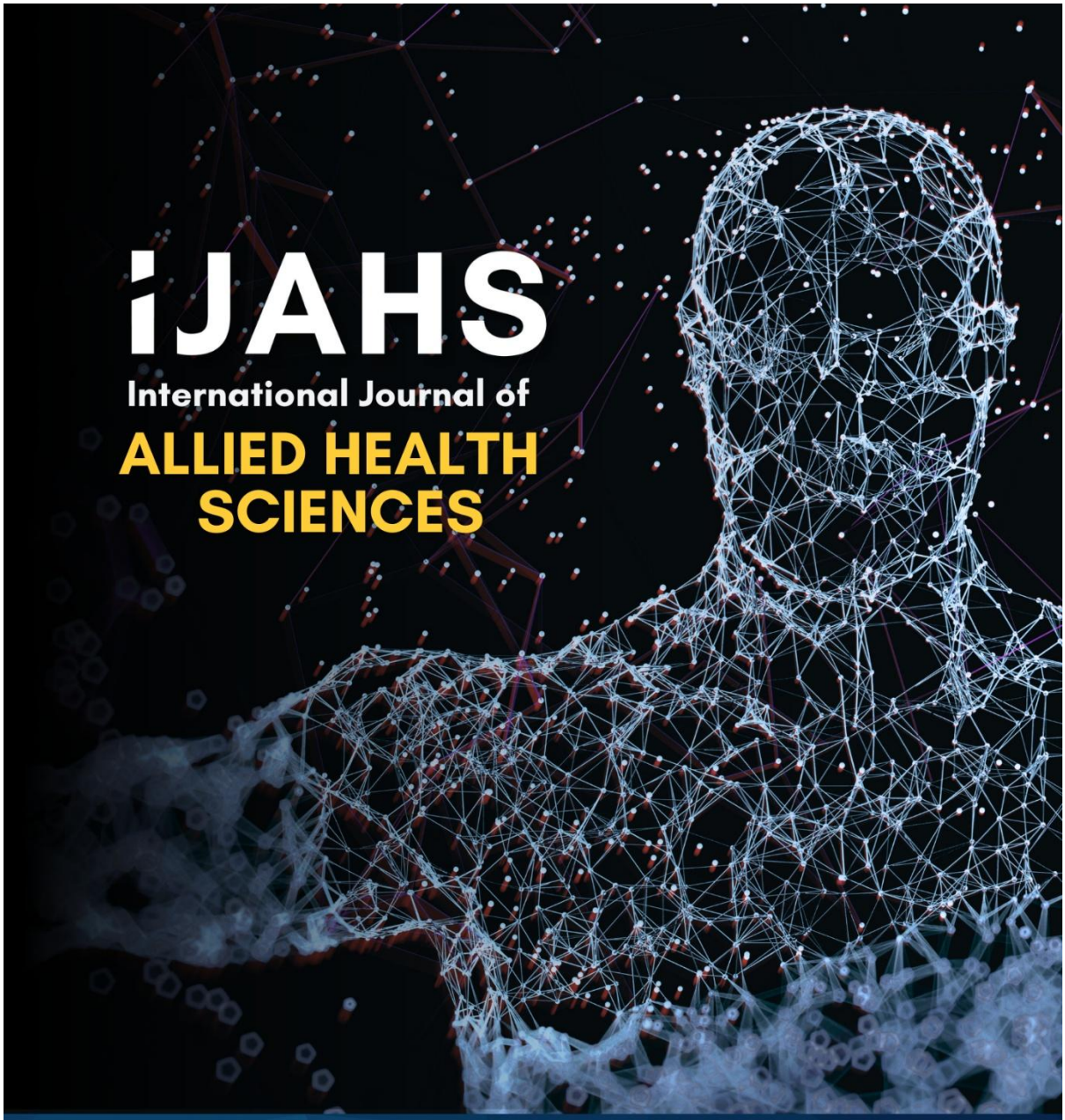

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Beyond Food Pyramids: Global Evidence, Local Plates

***Wan Azdie bin Mohd Abu Bakar*[1,2,*]**

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Food-based dietary guidelines have been used for decades as a keystone of public health nutrition. In many countries, food pyramids and plate-based models were developed and used as visual guides to complement nutrition education and health promotion programmes, helping societies understand healthy eating in an accessible manner. Such tools were not intended to prescribe identical diets across nations, but rather to translate nutritional information into culturally appropriate and food system specific guidance.

The recent release of the Dietary Guidelines for Americans (DGA) 2025-2030 has prompted a public debate internationally, including Malaysia. Much of the discourse centers on the perceived shifts in dietary emphasis, particularly stronger focus on "real food", dietary patterns and the reduction of ultra-processed foods. It places increasing emphasis on food quality, encouraging higher intake of fruits and vegetables, protein foods, dairy and healthy fats, while reducing the intake of refined grains and added sugars.

The move has been made mainly due to the rising burden of non-communicable diseases (NCDs) including obesity, diabetes and cardiovascular diseases, conditions that similarly affect Malaysia. While both countries share broad public health objectives, food-based guidelines cannot be imported from other countries. By design, dietary guidelines must be grounded based on local cultural practices, food availability, economic realities and lifestyle contexts.

Malaysia revised its national dietary guidance including the food pyramid with the launch of the Malaysian Dietary Guidelines (MDG) 2020. Its emphasis is more on limiting added sugars, particularly sugar-sweetened beverages and processed food, while promoting whole foods, fruits and vegetables, lean protein sources and whole grains. These recommendations are well aligned with contemporary nutrition science and reflect local evidence. Importantly, Malaysian Dietary Guidelines are framed within the context of multicultural society with distinct staple foods and established culinary traditions which differ substantially from Western countries.

Under the MDG 2020, the Malaysian Healthy Plate, commonly known as '*Suku-Suku Separuh*', remains relevant and practical tool for public nutrition education. The model, which guides plate portions to include one quarter carbohydrates, one quarter protein and half fruits and vegetables, emphasizing food quality, healthier choices and portion control. This approach directly addresses a major local challenge which is carbohydrate-heavy meals particularly rice, without demonizing staple foods or undermining cultural dietary identity but reinforcing moderation and balance.

Malaysia's current national food policy together with its food based dietary guidelines and the healthy plate framework are already on the right trajectory. The pressing challenge does not lie in redesigning the food pyramid or adopting foreign models, but in strengthening execution, consistency and public awareness within an increasing obesogenic food environment. The widespread availability of ultra-processed foods, frequent eating out and aggressive food marketing continue to undermine healthy eating efforts. Coordinated actions across ministries, health professionals and industry stakeholders on healthy eating and nutrition promotion are needed to realize the vision for a healthy Malaysia.

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ORIGINAL ARTICLE

Association Between Premenstrual Syndrome (PMS), Menstruation-Related Symptoms (MRS), and Physical Activity Participation Among Young Adult Women

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ABSTRACT

Background: Premenstrual syndrome (PMS) and menstrual-related symptoms (MRS) can have an unpleasant effect on women that negatively influence their ability to carry out regular activities including physical activity, exercise, and sport participation. Therefore, this article aims to investigate the prevalence and association of PMS and MRS toward young adult women's physical activity participation. **Methods:** This is a cross-sectional study that surveyed 131 young female adults aged 18-30 years old using a web-based online questionnaire made up of the sociodemographic section, and items from the Premenstrual Syndrome Questionnaire (PMS-Q), Menstrual Symptom Questionnaire (MSQ), and International Physical Activity Questionnaire - Short Form (IPAQ-SF). **Results:** Majority of the participants experienced mild degree of PMS severity (85.5%) and moderate degree of MRS frequency (66.4%). Higher severity of PMS was found, significant but weakly associated with higher physical activity participation ($r = 0.184$, $p<0.05$). However, frequency of MRS was not associated with levels of physical activity participation ($r =-0.093$, $p>0.05$). **Conclusion:** Our findings show association between both PMS and MRS toward the young female adults' physical activity participation levels. Further investigation with bigger sampling and wider age groups should be conducted to ascertain the findings.

INTRODUCTION

Almost 1.8 billion adults, representing about 31% of the world's adult population are not physically active with with women being less active than men (Strain et al., 2024). Numerous factors have been identified as determinants of adults' participation in physical activity, and these are generally categorized as biological, behavioral, psychological, social, or physical determinants (Aleksovska et al., 2019; Condello et al., 2017; Cortis et al., 2017; O'Donoghue et al., 2018; Kärmeniemi et al. 2018). For women, an important biological determinant of physical activity participation is the menstrual cycle, particularly the symptoms experienced during the premenstrual and menstrual phases (Gopalan, Mann, & Rhodes, 2024). Globally, 47.8% of women of reproductive age are affected by premenstrual syndrome (PMS). Among these women, about 20% experience symptoms severe enough to disrupt their daily activities, while the rest report mild to moderate symptoms (Direkvand-Moghadam et al., 2014).

PMS symptoms can affect women in multiple ways, including impairing physical and psychological functioning, and significantly disrupting productivity in their personal, social, and professional lives (Delara et al., 2012; Gudipally & Sharma, 2022; Loukzadeh et al., 2024; Schoep et al. 2019). PMS and MRS can have unpleasant effects on women challenging their ability to carry out regular activities including physical activity, exercise, and sport participation. However, the limited evidence available in the literature indicates that the impact of menstrual cycle–related symptoms on physical activity remains inconclusive (Kim et al., 2022). Prior studies have focused on examining the impact of physical activity levels on PMS and MRS among non-athlete populations (Shi et al., 2023; Sanchez et al., 2023; Romadona, 2021; Azhary et al., 2022; Bougault et al., 2023) as well as the effect of PMS and MRS on the sport and exercise performance among athletes (Carmichael et al., 2021; Brown et al., 2021; Bruinvels et al., 2021; Lima Trostdorf, 2021). Thus, the objective of this study is to investigate the prevalence and effect of PMS and MRS on physical activity participation among non-athlete young adult women.

MATERIALS AND METHODS

Study design

This is a cross-sectional study that surveyed the influence of PMS and MRS on physical activity participation among

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young adult women aged 18 to 30. Ethics was approved by the university research ethics committee. Sample size calculated with significant level and power set at 0.05 and 80%, respectively, was 123. Participants were recruited using convenience sampling among undergraduate university students. The web-based online questionnaire was distributed through social media platforms such as WhatsApp and Telegram. Candidates were considered eligible if they were young adult women aged 18 to 30 years and had experienced regular menstrual cycles for at least the past three months. Participants were excluded if they are currently pregnant or have chronic medical conditions affecting physical activity participation. Informed consent was obtained from participants by agreeing to proceed after reading consent statement on the first page of the web-based online questionnaire.

Research instruments

The web-based questionnaire consisted of four parts: a sociodemographic section, the Premenstrual Syndrome Questionnaire (PMS-Q), the Menstrual Symptom Questionnaire (MSQ), and the International Physical Activity Questionnaire–Short Form (IPAQ-SF). Sociodemographic data collected from all participants included age, height (cm), weight (kg), current contraceptive use, history of contraceptive pill use, and duration (in years) of contraceptive pill intake.

Premenstrual syndrome questionnaire (PMS-Q)

PMS-Q is a self-reported questionnaire used for measuring the severity of premenstrual symptoms (Kundu et al., 2019). The questionnaire comprised 26 items categorized into five domains of premenstrual symptoms, corresponding to the premenstrual tension (PMT) subgroups: anxiety, cravings, depression, hyperhydration, and other symptoms. (ElDeeb, Atta, & Osman, 2020; Hargrove & Abraham, 1982). Each item was rated on a three-point Likert scale: 1 (mild), 2 (moderate), and 3 (severe). The PMS-Q assesses the timing of symptoms, specifically whether they occur a week before menstruation, a week after, or at another time. To meet the diagnostic criteria for PMS, symptoms must develop a week before the period and diminish within a few days of the start of menstruation. No reliability or validity data is available for PMS-Q.

Menstrual symptom questionnaire (MSQ)

MSQ is a self-report measure aimed to evaluate menstruation symptoms including pain (Negriff et al., 2009). The questionnaire comprised 24 items, with participants selecting one of five response options to indicate the extent to which they experienced each symptom. Each item was scored on a scale from 1 (never) to 5 (always), with higher total scores indicating greater severity of menstrual symptoms. (Alkhatib et al., 2022). In this study, some items were excluded due to overlap with the PMS-Q, resulting in only 13 items being retained in the survey questionnaire. The MSQ has been reported as a reliable tool, with a Cronbach's alpha of 0.90 for the total scale and test–retest reliability ranging from 0.80 to 0.90 (Alkhatib et al., 2022; Li et al., 2023).

International physical activity questionnaire-short form (IPAQ-SF)

IPAQ-SF is a self-measure tool that consisted of seven items to quantify physical activity participation at four different intensity levels including vigorous-intensity activity, moderate-intensity activity, walking, and sitting (Craig et al., 2003). The frequency (measured in days per week) and duration (measured in time per day) of each specific type of activity are reported based on activities performed in the last seven days. Subsequently, Metabolic Equivalent of Task (MET) was calculated in accordance with the IPAQ recommendations. IPAQ-SF is reported to have a good to excellent test-retest reliability but low to moderate concurrent validity when compared to objective monitoring tools (Ács et al., 2021; Sand et al., 2017; Lee et al., 2011).

Data analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) software (version 29.0). A p-value of less than 0.05 was considered statistically significant. As for descriptive statistics, the frequency, valid percent, and cumulative frequency were used to present all the independent variables. For inferential statistics, Spearman's correlation test was used to analyze the association between variables, as the data were ordinal.

RESULTS

Participants characteristics

The sociodemographic profiles of the participants (N=131) who took part in this study are presented in Table 1. The majority of female participants were between 21 and 25 years of age (80.9%), not using any methods of contraception (93.9%), and reported no prior contraceptive pill use (97.7%).

Table 1: Sociodemographic Profiles of the Participants (N=131)

Baseline Characteristic	*n*	%
Age		
≤ 20	7	5.3
21 - 25	106	80.9
≥ 26	18	13.8
Present		
Contraception Pill	3	2.3
Other[a]	5	3.8
None	123	93.9
History of Contraceptive Pills		
No	128	97.7
Yes	3	2.3

Note. [a]Other contraceptive method: condom, female condom or diaphragm.

Premenstrual syndrome questionnaire (PMS-Q)

The majority of the participants experienced mild degree of premenstrual symptoms (PMS) severity (85.5%) with only 18 (13.7%) and 1 (0.8%) experienced moderate and severe level of PMS severity, respectively (Figure 1). Among those who responded as having mild degree of PMS severity, dizziness/fainting, headache, nervous tension, anxiety, and fatigue, were the most reported symptoms for PMS. Among participants who reported moderate and severe levels of PMS severity, the most frequently reported symptoms were mood swings (36.6%) and increased appetite (18.3%), respectively (Table 2).

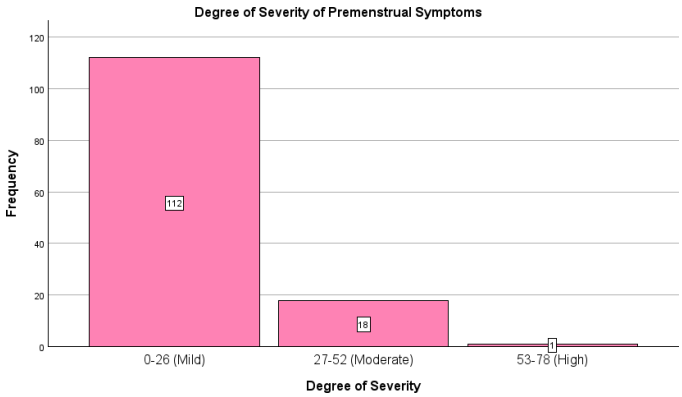

Figure 1: Degree of Severity of PMS Experienced by Female Undergraduate Students

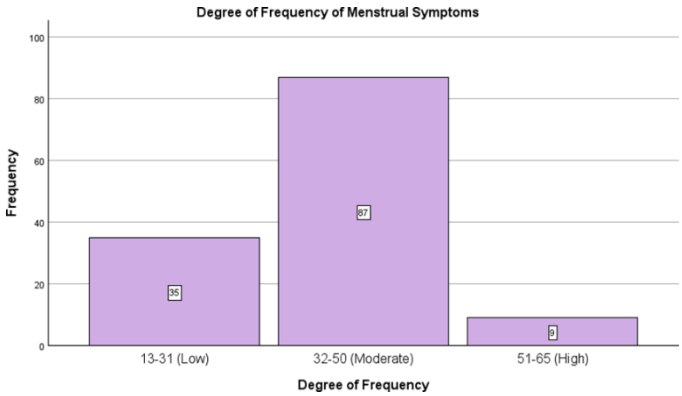

Figure 2: Degree of Frequency of Menstrual Symptoms Encountered by Female Undergraduate Students

Menstrual symptom questionnaire (MSQ)

The majority of participants reported a moderate frequency of menstrual symptoms (66.4%), while 35 participants (26.7%) and 9 participants (6.9%) reported low and high frequencies, respectively (Figure 2). Among the menstrual symptoms reported, nearly one-quarter (24.4%) responded to having always experienced tenderness on the first day of period at the lower back, abdomen, and inner thighs. More than one-third of the participants responded that they often experienced cramps and backache on the first day of menstruation (34.4% and 32.8%, respectively). Nearly one-third rarely experienced diarrhoea (28.2%), and feeling weak and dizziness (27.5%), during menstruation. Most participants did not use prescribed medication (40.5%) or aspirin (43.5%) during menstruation (Table 3).

Table 2: Premenstrual Symptoms and Its Severity Experienced by Female Undergraduate Students

	Degree of severity						
	Mild		Moderate		Severe		
Symptoms	*n*	%	*n*	%	*n*	%	Total
Anxiety	14	10.7	19	14.5	6	4.6	39
Irritability	12	9.2	27	20.6	15	11.5	54
Mood swings	6	4.6	48	36.6	16	12.2	70
Nervous tension	15	11.5	15	11.5	16	12.2	46
Appetite increase	10	7.6	36	27.5	24	18.3	70
Headache	16	12.2	29	22.1	16	12.2	61
Fatigue	14	10.7	32	24.4	14	10.7	60
Dizziness/fainting	17	13.0	14	10.7	16	12.2	47
Pounding heart	11	8.4	13	9.9	7	5.3	31
Depression	13	9.9	13	9.9	10	7.6	36
Crying	14	10.7	35	26.7	18	13.7	67
Forgetfulness	11	8.4	17	13.0	6	4.6	34
Confusion	8	6.1	16	12.2	5	3.8	29
Insomnia	6	4.6	14	10.7	4	3.1	34
Fluid retention	4	3.1	14	10.7	7	5.3	25
Weight gain	10	7.6	21	16.0	3	2.3	34
Swollen limbs	3	2.3	12	9.2	7	5.3	22
Breast tenderness	12	9.2	26	19.8	9	6.9	47
Abdominal bloating	12	9.2	22	16.8	10	7.6	44
Oily skin	8	6.1	24	18.3	4	3.1	36
Acne	8	6.1	29	22.1	11	8.4	48
Constipation	7	5.3	17	13.0	7	5.3	31
Diarrhea	7	5.3	8	6.1	2	1.5	17
Backache	8	6.1	34	26.0	12	9.2	54
Hives	2	1.5	10	7.6	4	3.1	16
Weakness & radiation down thighs	3	2.3	11	8.4	7	5.3	21

Note. All the symptoms and their severity were selected based on their occurrence one week prior to the start of period.

Association between PMS, Menstrual Symptoms, and Physical Activity Participation

The Spearman's correlation coefficient between the severity of PMS and the level of physical activity was 0.184 ($p<0.05$). This indicates a significant although weak positive correlation, suggesting that there was a slight tendency for higher severity of premenstrual symptoms to be associated with higher physical activity participation (Table 4).

Table 3: Menstrual Symptoms and Its Frequency Encountered by Female Undergraduate Students

	Degree of Frequency									
	Never		Rarely		Sometimes		Often		Always	
Symptoms	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
I have cramps that begins on the first day of my period.	6	4.6	23	4.6	30	22.9	45	34.4	27	20.6
I only know that My period is coming by looking at the calendar.	10	7.6	18	13.7	57	43.5	28	21.4	18	13.7
I take a prescription drug for the pain during my period.	53	40.5	35	26.7	19	14.5	16	12.2	8	6.1
I feel weak & dizzy during my period.	13	9.9	36	27.5	37	28.2	29	22.1	16	12.2
I have diarrhea during my period.	36	27.5	37	28.2	34	26.0	15	11.5	9	6.9
I take aspirin for the pain during my period.	57	43.5	25	19.1	29	22.1	15	11.5	5	3.8
My lower back, abdomen & inner sides of my thighs begin to hurt or tender on the first day of period.	12	9.2	30	22.9	36	27.5	21	16.0	32	24.4
During the first day or so of my period, I feel like curling up in bed or taking a hot bath.	14	10.7	22	16.8	35	26.7	34	26.0	26	19.8
I am constipated during my period.	32	24.4	32	24.4	39	29.8	18	13.7	10	7.6
Beginning on the first day of my period, I have pain which may disappear for several minutes and then reappear.	6	4.6	30	22.9	38	29.0	33	25.2	24	18.3
The pain I have with my period is not intense but a continuous dull aching.	8	6.1	29	22.1	44	33.6	35	26.7	15	11.5
I have backaches which begin the same day as my period.	8	6.1	21	16.0	36	27.5	43	32.8	23	17.6
I have nauseous during the first day or so of my period.	27	20.6	23	17.6	39	29.8	29	22.1	13	9.9

Table 4: Association between premenstrual symptoms and physical activity participation.

Variable	Severity of PMS	Level of physical activity
Severity of PMS	-	0.184*
Level of physical activity		-

Note. N=131. Spearman's rho reported. *p<0.05.

The Spearman's correlation coefficient between the frequency of menstrual symptoms and the level of physical activity was -0.093 (p>0.05), indicating no statistically significant association. This indicates that higher frequency of menstrual symptoms was not associated with lower levels of physical activity (Table 5).

Table 5: Association between menstrual-related symptoms and physical activity participation

Variable	Severity of menstrual symptom	Level of physical activity
Severity of menstrual symptom	-	-0.093
Level of physical activity		-

Note. N=131. Spearman's rho reported. *p<0.05.

DISCUSSION

This study aimed to investigate the prevalence and association between PMS and MRS towards young adult women's physical activity participation. The majority of the participants were reported to have mild degree of PMS severity (85.5%) and moderate degree of menstrual symptoms frequency (66.4%). These findings are higher as compared with other studies that reported mild PMS severity ranges between 37% and 67.5% (Tolossa et al., 2014; Bhandari et al., 2023), and moderate menstrual symptoms frequency ranges between 29.8% and 56% (Teul et al., 2014; Karout et al., 2021), respectively.

Higher severity of premenstrual symptoms was found to be significantly, though weakly, associated with higher physical activity. This is in contrast with studies which reported that PMS did not directly influence physical activity participation among adult women but indirectly affected their quality of life. It was reported that PMS significantly reduced the quality of life of adult women aged 18-23 but not on physical activity participation (Elvan, 2023; Bhuvaneswari et al., 2019; Pinar et al., 2011). In contrast to this study, Shehata and colleagues (2024) reported that the severity of PMS was significantly associated with lower physical activity participation among adult women aged 20-35 compared to those with moderate or high physical activity participation. A similar significant association between PMS severity and physical activity participation among adult women aged 18–35 was reported by Sevak et al. (2024). These findings suggest that among adult women, severe PMS may act as a barrier to physical activity participation, as PMS severity measured by the Premenstrual Syndrome Scale (PMSS) was found to significantly influence the exercise barriers subscale score of the Exercise Benefits/Barriers Scale (EBBS) (Kiloatar & Kurt, 2024). The differing findings in this study may suggest that young adults use physical activity as a coping strategy to alleviate PMS severity (Yang et al., 2024; Dehnavi et al., 2018).

This study found no statistically significant association between the frequency of menstrual symptoms and levels of physical activity, in contrast to previous literature. In the study by Prince and Annison (2022), 90% of adult women aged 18–59 reported that menstruation negatively affected their participation in adventurous activities such as mountaineering, camping, swimming, running, climbing, kayaking, mountain biking, and canoeing. Similarly, Bruinvels et al. (2021) reported that higher MRS scores, as measured by the Menstrual Symptom Index (MSi), were associated with a greater likelihood of missing or modifying physical activity participation among adult women with a mean age of 38.3 years. Nearly half of adult

women with a mean age of 24.1 years had to refrain from planned physical activity due to MRS particularly menstrual pain (Linda et al., 2022). In addition, menstruation patterns also may influence physical activity participation. Adult women with a mean age of 24.1 years and regular menstruation pattern have been reported to have higher physical activity participation compared to those with irregular menstruation patterns (Kim, Kang, & Jeong, 2022). The combined menstrual irregularity and MRS may further complicate physical activity participation among adult women of reproductive age.

This study had few limitations. The data obtained and analyzed was self-reported using questionnaires and may be influenced by recall bias. Other confounding factors such as menstrual cycle regularity was not assessed in this study that may result in different physical activity participation. It is recommended that future research include larger samples while accounting for individual variability, such as menstrual cycle regularity and its effect on physical activity participation.

CONCLUSION

In this study, the majority of participants reported mild PMS severity and a moderate frequency of menstrual symptoms. A significant, though weak, positive association was observed between PMS severity and physical activity, suggesting that young adults may use physical activity as a coping strategy to alleviate PMS symptoms (Yang et al., 2024; Dehnavi et al., 2018). No association was found between menstrual symptoms severity and levels of physical activity. Therefore, tailored education should be strategised to facilitate young adults on managing menstrual health and maintaining physical activity, encouraging positive outcomes of both physical and mental well-being.

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ORIGINAL ARTICLE

Parental Experiences in Speech and Language Intervention for Late Talkers: A Qualitative Study

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ABSTRACT

Background: Late talking is a common reason for referral to speech and language services, yet little is known about parents' lived experiences within intervention contexts. This study explored parental perspectives on speech and language interventions for late talkers (LTs), with a focus on their roles in conjunction with those of speech–language therapists (SLTs). **Methods:** This study employed a qualitative exploratory design. Semi-structured phone interviews were conducted with six parents of LTs aged 24–48 months, all of whom had attended at least three intervention sessions with SLTs. Interviews were then transcribed verbatim, and data were examined using qualitative content analysis. **Results:** Two overarching themes were identified: (1) SLTs' practices during language intervention and (2) parents' practices during language intervention. Under the first theme, parents reported that SLTs conducted assessments, developed tailored intervention plans, implemented varied approaches, and provided feedback alongside home assignments. It was evident, however, that SLTs were usually the leading figures in planning, with parents positioned primarily as recipients of these plans rather than active collaborators in setting goals. Under the second theme, parents described their own practices, which included discussing their child's needs with SLTs, assisting during therapy sessions in flexible ways, learning through both direct coaching and external sources such as workshops, and adapting strategies to daily routines at home. Parents also reported variations in their level of involvement during sessions, ranging from active participation to passive observation or absence, depending on the child's cooperation and the SLT's guidance. **Conclusion:** Findings highlight the dual roles of SLTs and parents in supporting LTs, with parents extending intervention beyond sessions and actively seeking learning opportunities. However, their involvement was uneven, reflecting diverse roles within therapy and varied opportunities for collaboration. These insights underscore the importance of strengthening family-centred practices to optimise engagement and outcomes.

Keywords:
Late talkers; parent perspectives; speech and language therapy

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INTRODUCTION

The most frequent reason children are referred to professionals is late talking (Jayanath & Ozonoff, 2020). As late talking is a symptom of numerous conditions, late-talking children form a heterogeneous group (Rescorla, 2011). Thus, they may have other conditions that affect their ability to acquire speech and language skills, such as hearing problems or developmental disorders. However, there is a subset of children who exhibit delayed language development without any other apparent developmental concerns. These children are typically referred to as "late talkers" (LTs) (Rescorla, 2009, 2011; Singleton, 2018). LTs are characterised by delays primarily in expressive language, or in both expressive and receptive language, compared to their age-matched peers (Morgan et al., 2020). Specifically, LTs who produce fewer than 50 words or do not combine words by 24 months of age are considered at risk for persistent language difficulties (Chilosi et al., 2019; Rescorla, 2011). Therefore, early intervention is crucial for mitigating these risks and supporting language development.

Intervention for LTs is commonly given by speech-language therapists (SLTs). Deveney et al. (2017) described two intervention approaches that SLTs can conduct during speech and language intervention for children: clinician-directed intervention and parent-implemented language intervention. Clinician-directed intervention is also known as direct intervention. Within this type of intervention approach, SLTs are commonly the agents of change (Rhodes, 2017), as they act as the primary interventionists who provide direct therapeutic services to children with speech and language problems (Deveney et al., 2017).

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Parent-implemented language intervention, also known as indirect intervention, is underpinned by principles of family-centred care (Espe-sherwindt & Serrano, 2016). This approach empowers parents as the primary interventionists, enabling them to implement suitable strategies that promote parent-child interaction through training. The premise of the approach is that improving parents' use of effective communicative behaviours that facilitate language development in naturally occurring routines will accelerate children's language learning in functional contexts when the children are motivated to interact with their parents (Heidlage et al., 2019). Recent meta-analyses confirm that parent-implemented language intervention has significantly fostered children's language development (Bernabe-Zuñiga et al., 2025; Cheng et al., 2023).

Although the American Speech-Language-Hearing Association (ASHA, 2016) has delineated the professional roles of SLTs in intervention, empirical evidence indicates that SLTs' own perceptions of their roles extend beyond these formal definitions and vary across contexts. Davies et al. (2019) reported that SLTs primarily emphasised clinical responsibilities such as planning, delivering treatment, and providing coaching to families, reflecting a more traditional, clinician-centred view. In contrast, Shobbrook et al. (2025) demonstrated a shift towards broader roles, with SLTs conceptualising themselves as agents of change who not only assess and advise but also empower parents and train others to deliver interventions. Taken together, these findings suggest an evolution in professional identity, moving from a narrow focus on direct intervention to a more dynamic and collaborative model of practice.

However, while these studies underscore the expanding scope of SLTs' responsibilities, comparatively little is known about how parents themselves perceive and enact their roles within language intervention. Given that parents are central partners in facilitating children's communication outcomes, understanding their perspectives and experiences is essential for developing family-centred and sustainable intervention practices. This study, therefore, seeks to address this gap by examining parental experiences in speech and language intervention with particular attention to late talkers.

METHODS

Research Design

This study was part of a larger study that interviewed SLTs and parents of LTs. The present paper focuses on the parental perspective, employing a qualitative exploratory design to gain an in-depth understanding of their experiences with speech and language intervention for LTs. Semi-structured interviews were used as the primary data collection method, as they allow researchers to explore participants' thoughts, feelings, and beliefs in a flexible yet guided manner (Dejonckheere & Vaughn, 2019).

Interview Guide Development & Pilot Study

The research team developed an interview guide to ensure consistency across interviews while allowing for follow-up probing. The interview guides comprised two parts. Patton (2002) stated that experience-related questions require minimal recall and interpretation, which is easier to answer than opinion-related questions. Hence, the first part of the interview focused on parents' experiences during language intervention. In addition, the second part, which was not the focus of the present paper, examined parents' perspectives on the design of a parent-implemented language intervention programme. Following that, a pilot study was conducted with four parents of LTs to refine the guide. The pilot study aimed to evaluate the coverage, clarity, and relevance of the questions and to identify areas requiring refinement (Kallio et al., 2016). Feedback from the pilot study led to several revisions, including rephrasing questions for clarity and incorporating additional probes to elicit richer responses. For instance, a probe on what ST did during their first session was added, as parents tended to describe only the intervention part.

Participants

Parents were recruited based on the following inclusion criteria: 1) having a late-talking child aged 24–48 months at the time of the first appointment with a SLT, 2) the child had undergone a formal language assessment and attended at least three intervention sessions with an SLT, and 3) parents were fluent in the Malay language. Exclusion criteria included children with language difficulties stemming from cognitive, sensory, or developmental disorders.

Recruitment took place through multiple channels, including advertisements on social media platforms and referrals from SLTs who shared information about the study with eligible families. A total of 29 parents initially expressed interest. After screening, six parents fulfilled the eligibility criteria and agreed to participate. Table 1 presents further information on the participating parents.

Table 1: Parents' demographic details

Participant	Ethnicity	Gender	Age	Education Level
P1	Malay	Female	43	Professional qualification
P2	Malay	Male	33	Master degree
P3	Malay	Female	40	Bachelor's degree
P4	Malay	Female	37	High school
P5	Malay	Female	38	Master degree
P6	Malay	Female	36	Bachelor's degree

Procedure

Ethical approval for this study was obtained from the Research Ethics Committee of the International Islamic University Malaysia. Interested parents were initially contacted by phone and email and provided with an information sheet explaining the study's purpose, procedures, and ethical considerations. Verbal consent was obtained during the briefing, after which the consent form and demographic questionnaire were sent to the participant via email. Parents were given one week to consider their involvement and were required to return a signed consent form and a completed demographic form. Written informed consent also covered participation, audio recording, and the use of anonymised data for academic purposes.

Following that, phone interviews were arranged at times convenient for the parents, with each session lasting approximately 30 to 45 minutes. Since Malay is the official language of Malaysia and the first language of all participants, interviews were conducted in Malay. Phone interviews were selected as the method of data collection because the participants were geographically dispersed, and this method reduced potential connectivity issues that may arise with online meeting platforms. With participants' consent, all interviews were audio-recorded using a digital voice recorder, with the phone placed on loudspeaker mode to ensure the accurate capture of the conversation.

Data Analysis

All interviews were transcribed verbatim by the first author and analysed in Malay. For reporting purposes, selected quotations were translated into English using a meaning-based approach, which emphasises preserving the original intent and contextual meaning rather than literal translation (Marschan-Piekkari & Reis, 2004). This method was preferred, as direct translation often results in producing stilted or awkward phrasing (Harzing et al., 2011).

The data were analysed following the qualitative content analysis framework described by Graneheim and Lundman (2004). The process involved multiple readings of transcripts to gain familiarity with the data, followed by the identification of content areas based on the research questions. These areas were divided into meaning units, which were subsequently condensed while retaining their essential meaning. Condensed units were then coded and categorised. Finally, categories were organised into overarching themes that captured the essence of parents' experiences. The analysis was conducted collaboratively by the research teams to enhance credibility. A consensus was reached through repeated discussions and revisions during the coding, categorisation, and theme development phases.

RESULTS

Content analysis of the interviews revealed two overarching themes: (1) SLTs' practices during language intervention and (2) parents' practices during language intervention. Within these themes, several categories emerged. The categories for each theme are listed in Table 2.

Theme 1: Speech–Language Therapists' Practices during Language Intervention

There were four categories under this theme: (1) conduct assessments, (2) develop intervention plans, (3) implement various intervention approaches, and (4) provide feedback and home assignments. For the first category, parents described how the initial sessions were often allocated to identify areas of difficulty by conducting assessments to evaluate their child's communication abilities and understand their preferences. One parent explained:

"So, in that first session, the therapist was more focused on finding out what the actual issue was, based on different language components. The therapist also asked about the things my child liked and sought confirmation on whether my child truly understood certain words or was responding out of routine." (Parent 2)

Table 2: Summary of themes and categories emerged

Themes	Categories
Speech–language therapists' practices during language intervention	1) Conduct assessments 2) Develop intervention plans 3) Implement various intervention approaches 4) Provide feedback and home assignments
Parents' practices during language intervention	1) Discuss their child's needs 2) Assist SLTs 3) Learn through multiple methods 4) Adapt strategies to the home environment

Another parent recalled that the evaluation was relatively brief due to the child's young age, yet still provided valuable insight into strengths and needs:

"The therapist examined my child… My son was just two years old, so the evaluation did not take long. After that, the therapist informed me that my child's comprehension was good, except that he could not express himself." (Parent 5)

The second category involves developing intervention plans tailored to the child's specific needs. Parents described how SLTs transformed assessment findings into structured intervention plans. One parent mentioned that her SLT created a "special syllabus" after identifying her child's challenges. At the same time, another remembered being given specific guidance to work on at home towards achieving language targets:

"After that, the therapist mentioned the things that needed to be taught and to familiarise my son with those at home. During the first therapy session, she encouraged me to get him to say 'want.' Then, in the third session, she just told me to focus on increasing his vocabulary." (Parent 5)

The shared intervention plans provided clear direction, allowing parents to adjust their home support accordingly. However, it can be seen that SLTs were usually the main person in planning, with parents often positioned as recipients of these plans rather than active collaborators in setting goals.

The third category focused on implementing various intervention approaches, ranging from child-led to adult-led and clinician-directed to parent-implemented approaches. SLTs were described as employing a range of techniques and activities, including play-based activities and shared book reading, while applying vocabulary drills or language stimulation strategies. The degree of parent involvement during these intervention sessions also varied. Parents described a range of roles during therapy sessions, from active participation to minimal involvement, and even being asked to step out to support their child's cooperation. One parent, for example, recalled being invited to join in when her child resisted engagement:

"SLT asked me to play with her when my child did not want to cooperate. My child would join the activity when he saw me play with the SLT." (Parent 4)

However, in other sessions, the role of the same parent was minimal, reflecting a more clinician-directed approach:

"The therapist was the one who would teach my son. I just sat at the side." (Parent 4)

She also recounted moments of explicit parent coaching, where the SLT observed her and her husband's interactions with their child and provided corrective feedback:

"The SLT also observed how my husband and I interact with our child. Then the SLT commented, 'You cannot do this and this. You should do this and this.' We should change based on the comments." (Parent 4)

In contrast, another parent highlighted situations where the SLT asked her to leave the therapy room altogether, to encourage the child's cooperation:

"Sometimes, when I was in the therapy room, my child did not want to cooperate. The therapist then instructed me to wait outside." (Parent 1)

These varied approaches demonstrate how parental involvement was fluid and dynamic, shaped by the child's responsiveness as well as the SLTs' clinical judgment.

The fourth category, providing feedback and home assignments, encompassed the ways SLTs kept parents informed about their child's development while equipping them with information on how to continue intervention at home. Parents consistently reported receiving verbal feedback at the end of each session, which outlined the activities completed, the child's achievements for that

session, and the next set of intervention goals. For some families, these updates came in the form of verbal guidance, while for others, they were supplemented by tangible materials, such as worksheets or activity suggestions. When parents could not attend a session, some SLTs also used creative solutions to keep them engaged:

"If I did not join the therapy session, SLT will send me a video and instruct me on what to do at home. She will also share with me what she did during the session. The video is like a guideline for me." (Parent 1)

These exchanges, whether through verbal updates, printed materials, or video demonstrations, reinforced the collaborative nature of the intervention, extending its impact from the clinic into the home environment and maintaining continuity between sessions.

Theme 2: Practices of Parents during Language Intervention

Four categories were identified for this second theme: 1) discuss their child's needs, 2) assist SLTs, 3) learn through multiple methods, and 4) adapt strategies to the home environment. The first category involved discussing their child's needs. Parents described these conversations as opportunities to gain clarity on their child's progress, seek advice, and address broader concerns such as educational placement. One parent explained:

"I discussed with my therapist about schooling. I asked her whether I needed to enrol my son in a special school in the future. My therapist said 'no' because my son only has a language delay. He does not have other problems." (Parent 1)

Such discussions were often reassuring, giving parents the confidence to make informed decisions.

The second category centred on assisting SLTs during sessions. While some parents actively stepped in to encourage participation, others adjusted their involvement according to the child's mood and level of engagement. One parent described:

"Sometimes, I joined the activities although SLT did not ask me since my child refused to talk with the SLT. When I talked, she automatically talked." (Parent 6)

Flexibility was key, as illustrated by another parent:

"Sometimes, I would leave my child with the SLT. Sometimes, I stayed in the therapy room." (Parent 1)

These choices reflected a nuanced understanding of their child's behaviour and an effort to create optimal conditions for learning.

The third category concerned learning through multiple methods. Beyond in-session observation, parents sought additional knowledge through other resources such as workshops, recognising the value of repeated exposure to similar content:

"…any workshop which I could reach out to, I will try to attend. I do not mind if it covers the same thing, I still want to attend." (Parent 6)

Such proactive learning demonstrated parents' commitment to enhancing their skills and supporting their child's language growth.

The final category, which is adapting strategies to the home environment, reflected how parents personalised the techniques learned during sessions to suit their family routines and living contexts. Rather than replicating therapy activities in a structured format, many parents integrated them into daily interactions, such as during meals, playtime, or household chores.

"I do not do table activities; I use all the techniques during daily routine activities. For example, each time we do something, I say the word repeatedly and encourage him to say it too, or use any suitable technique." (Parent 5)

In some cases, this adaptation also applied to homework assignments given by SLTs. Parents described adjusting the timing and format of these tasks so that they could be completed without adding more tasks to their schedules. Nonetheless, they still some pressure to complete them as instructed:

"I do the homework as part of our routine. I don't take out the worksheet the SLT gives and do it with my child right away. I review it first, then do it when I'm free and mark it afterwards. But I am worried that if I don't have time to do it, the SLT might think I'm lazy." (Parent 6)

This flexibility allowed parents to maintain consistency in implementing strategies or completing tasks without disrupting family life.

DISCUSSION

This study examined parental experiences with speech and language interventions for LTs and highlighted the dual roles of SLTs and parents within intervention contexts. Two overarching themes emerged: the practices of SLTs

during intervention and the practices of parents in supporting and adapting intervention strategies. The findings provide valuable insights into the evolving partnership between professionals and parents, highlighting both the strengths and gaps in current practice.

With respect to parental perspectives on SLTs' practices, the findings reflected many of the practices reported by SLTs in earlier studies. For instance, SLTs have described conducting assessments, developing intervention plans, collaborating with parents to varying degrees from observation to parent-led intervention, and providing home assignments to support continuity of therapy (Tukiran et al., 2023). Similarly, research has shown that SLTs often model and teach strategies before parents become actively involved or provide specific instructions for parents to follow during therapy sessions (Melvin et al., 2023). These parallels highlight consistency between SLT-reported practices and parents' lived experiences.

A key finding concerned the considerable variation in parental involvement during therapy sessions. Parents described a spectrum of roles, ranging from active participation to passive observation, and even waiting outside the therapy room. Such variation reflects diverse understandings of parental roles, as some parents perceived themselves as co-interventionists, while others deferred responsibility to SLTs. This resonates with previous studies, which identified a spectrum of parental roles in intervention, ranging from modelling therapy targets alongside SLTs to adopting a primarily observational stance (Davies et al., 2017; Phoenix et al., 2020). Interestingly, a recent study suggests that this fluidity in involvement was guided not only by SLTs' preferences but by parents' emphasis on their child's happiness, safety, and cooperation (Klatte et al., 2024)., Therapists should adapt their therapeutic approach to reflect not only the child's needs but also the family's preferences and priorities

Parents also consistently reported engaging with therapy beyond the clinic. They described completing home tasks assigned by SLTs and embedding therapeutic strategies into everyday routines, even when their participation during sessions was limited. This aligns with Watts Pappas et al. (2015), who reported that while parents often perceived SLTs as the primary agents of therapy within clinical settings, they assumed personal responsibility for continuing intervention at home. These findings suggest that parents conceptualise their roles as complementary to, rather than substitutive of, the therapist's, thereby reflecting a hybrid model of clinician- and parent-implemented care. Interestingly, these findings contrast with reports from SLTs who described limited parental follow-through as a key challenge, particularly when therapy activities were not consistently carried out at home (Tukiran et al., 2023). This divergence may reflect variability across families, differences in how SLTs communicate expectations, or the extent to which parents feel supported and confident in implementing strategies, underscoring the complexity of sustaining intervention beyond the clinic.

Another important finding was that the parents in this study engaged in learning not only through their interactions with SLTs but also via external sources such as workshops and online resources. While previous research has consistently documented parents as learners within therapy sessions primarily through observation, feedback, and direct teaching (Davies et al., 2019; McKean et al., 2012; Phoenix et al., 2020), the present study highlights parents' agency in independently seeking knowledge beyond the therapy room. This proactive pursuit of learning reflects parents' recognition of their central role in supporting language development and their willingness to invest in developing skills to meet their child's needs. In addition, digital and technology-assisted approaches have emerged as valuable supplements, offering parents flexible access to training, modelling, and professional guidance (Hall & Bierman, 2015). The rapid expansion of digital learning platforms during and after the COVID-19 pandemic further underscores the feasibility of such modalities for supporting parents' learning (Korkmaz & Toraman, 2020). By broadening the avenues through which parents can access intervention knowledge, service providers may enhance both engagement and outcomes for families of LTs.

However, despite these diverse forms of engagement, a notable gap emerged in the area of intervention planning. Parents in this study reported minimal involvement in planning and goal setting, despite being actively engaged in treatment and home-based activities. This is concerning given that family-centred care frameworks emphasise parental involvement at all stages of intervention, including collaborative planning (Kokorelias et al., 2019). Yet, in practice, collaboration often reflects a one-directional model where therapists set goals, assign home activities, and provide strategies without fully integrating parents' perspectives (Melvin et al., 2023). Limited engagement in planning may constrain opportunities to align intervention goals with family priorities and cultural contexts, which are critical for sustainable outcomes.

CONCLUSION

In summary, these findings underscore the evolving yet uneven nature of parent–SLT partnerships in supporting LTs. While parents demonstrate strong commitment through home practice and independent learning, their limited involvement in intervention planning highlights a persistent gap between family-centred ideals and clinical realities. Addressing this imbalance requires service models that not only value parents as active partners in implementation but also empower them as equal contributors to decision-making, thereby strengthening both engagement and long-term outcomes.

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ORIGINAL ARTICLE

Development of a Malaysian Web-based Application to Support Caregivers of Children with Amino Acid Metabolism Disorders (AAMDs)

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ABSTRACT

Background: Individualised dietary intervention is paramount in the treatment of amino acid metabolism disorders (AAMDs). However, dietary monitoring was perceived as tedious as it required minute weighting of the food items and a complex calculation process. The present study aims to elaborate on the development and content validation of MyProteinGuide™, a web-based application among caregivers of children with AAMDs. **Methods:** The overall content of the MyProteinGuide™ was shaped by the results obtained during a needs assessment and supported by an evidence-based approach which consists of self-monitoring features and informative educational content. Content validation was then carried out among nine healthcare professionals. **Results:** The overall CVI of the module was 0.983, which was deemed validated for content. Suggestions for improvements to MyProteinGuide™ in terms of content features included having a wide variety of menu and recipes, using different household measurements as units in food diary and a specifically labelled growth chart. In terms of language and GUI, using a uniform colour scheme and standardisation of language was suggested. **Conclusion:** Improvements to the application according to healthcare experts' comments should be addressed to optimize the usage of MyProteinGuide™ among caregivers of children with AAMDs.

INTRODUCTION

Amino acid metabolism disorders (AAMDs) manifest through a deficiency in functional enzymes or transporters, resulting in the accumulation of normal or unusual compounds such as amino acids, ammonia, and organic acids in proximity to the metabolic impediment. AAMDs can be further classified into three subgroups such as urea cycle disorders (UCD), organic acidurias (OA) and aminoacidopathies (AA) (Ferreira et al. 2021). Among all subclasses of AAMDs, AA such as Maple Syrup Urine Disease (MSUD) and Phenylketonuria (PKU) was the most prevalent disorders in Malaysia (Lim et al., 2023). This accumulation can cause acute or progressive intoxication (Ezgu, 2016; Saudubray et al., 2016). In the management of AAMDs, a lifelong, personalized protein-restricted diet holds crucial significance. This diet serves to reduce the production and deposit of toxic metabolites as well as to prevent catabolism by providing adequate macronutrients (Frazier et al., 2014; Jurecki et al., 2019; van Wegberg et al., 2017)

This diet demands a high degree of adherence on the part of all family members which significantly affects the quality of life (QoL) of both the patients and their caregivers (Bosch et al., 2015; Eminoglu et al., 2013; Fabre et al., 2013; Shaji Thomas et al., 2021). This is evident in the daily food preparation process, which includes meticulous weighing and calculations for accurate natural protein intake, which are viewed as time-consuming (Fabre et al., 2013). Besides the tedious calculation process, caregivers are tasked with preparing the daily menus for their children, often involving extra cooking due to the children's inability to consume the regular family diet (Eijgelshoven et al., 2013). Simultaneously, there is a need to adjust the natural protein intake over time, given its customization based on individual factors such as the severity of the condition (including residual enzyme

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activity), age, growth rate, and metabolic control (MacDonald et al., 2012). In addition to that, caregivers need to possess comprehensive knowledge regarding the preparation of their children's daily diet, incorporating a wide variety of low-protein ingredients to prevent monotony in their meals (Lim et al., 2022).

With rapid integration of digital health monitoring for the improvement of quality of life, it was found that diet tracking mobile applications can ease the monitoring of patients' daily nutrient intake. These applications auto-calculate the energy and macronutrients of every food item entered, and then compare the results to the patient's individual requirements determined by their dietitian (Ho et al., 2020). Hence, similar concept was proposed among patients with AAMDs (Ho et al., 2016). Dietitians may require less time analyzing diet recall during diet consultations, freeing up more time spent in providing nutrition education. The dietary application's ability to provide instant analysis of children's daily natural protein intake can motivate caregivers to track their children's protein intake for longer periods, thus promoting self-monitoring and sense of self-efficacy.

A plethora of mobile and web-based applications specifically for patients with AAMDs is now available in mobile app stores and on web pages. Their roles as dietary self-management tools for patients with AAMDs can be used in a variety of ways, including as protein and specific amino acid trackers, food diaries, digital food composition databases, and nutrition recommendation providers (Ho et al., 2016). In terms of content, Lim and colleagues assessed six mobile applications that are commercially available and designed for people with metabolic disorders, and found several limitations (*unpublished data*). Firstly, the food composition database in most self-management systems available in the market is not culturally appropriate for use in Malaysia. This is because these systems were developed in Western countries, such as Germany and Canada, and may not suit the dietary habits of the local Malaysian population due to differences in language, culture, and health behaviour. Besides that, the basic educational materials are mostly not adopted from credible clinical guidelines. The educational materials are also often too lengthy, and do not use graphics to describe the pathophysiology of disorders. Instead, they only focus on delivering the nutritional content of food and monitoring the dietary intake of the patient (Ho et al., 2016). Furthermore, the systems lack anthropometric and biochemical monitoring, as well as elements of nutritional education such as low protein recipes. Importantly, none of these applications have been validated by healthcare professionals with experience in managing metabolic disorders. To date, neither a web-based nor a mobile application has been developed specifically for patients with AAMDs in Malaysia. Hence, this study aimed to develop and evaluate a web-based application specifically for patients with AAMDs in Malaysia, using the Malaysian food composition database as a reference.

MATERIALS AND METHODS

This study consisted of three phases. In Phase 1, a needs assessment was conducted using a mixed-methods approach. This involved organizing focus group discussions (FGD) and questionnaire surveys with caregivers of patients with AAMDs were conducted (Lim et al., 2023). Phase 2 involved developing and validating the MyProteinGuide™ among healthcare professionals, including dietitians and clinical geneticists, while Phase 3 commenced a cross-sectional study to evaluate the usability of the web-based application among caregivers (not reported in this manuscript).

System development

MyProteinGuide™ was developed using the IDEAS framework (Integrate, Design, Assess and Share), which was developed by Mummah and colleagues (Mummah et al., 2016) to create digital health behaviour change interventions. The IDEAS framework proposes a four-step approach, including integrating the needs of the caregivers of patients with AAMDs, which were identified through the FGDs and qualitative survey (Lim et al., 2023), followed by designing the contents iteratively and rapidly together with group of experts consisting of lecturers from the dietetic programme, a clinical psychologist, a metabolic dietitian and a consultant clinical geneticist. After that, assessment of the application was carried out via usability testing among the caregivers. Sharing was carried out via the publication of this article. The interface for signing up for a new account is shown in Figure 1. The overall description and content features of the MyProteinGuide™ are described in the section below.

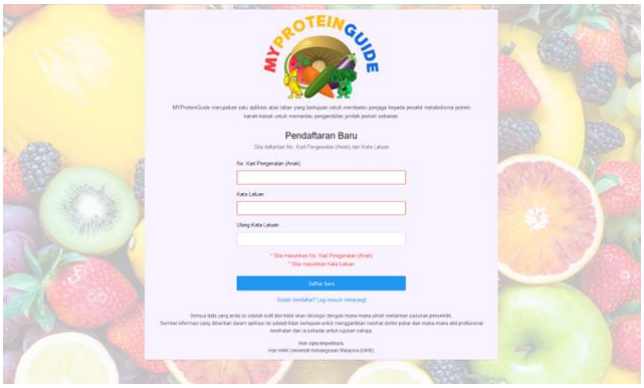

Figure 1: Interface signing up a new account

Personal profile

Once users create an account, they can enter the child's sociodemographic profile, such as birthdate, gender, and race (Figure 2). Furthermore, the caregivers need to fill in their child's energy, total protein, and total natural protein requirement based on the prescription given by their clinical geneticist and metabolic dietitian during each clinic appointment. The total energy requirement for children with AAMDs is usually determined by the metabolic dietitian based on the child's age and gender, according to the Malaysian Recommended Nutrient Intake (RNI) 2017 (Ministry of Health Malaysia, 2017), as the energy requirement of AAMDs children is similar to that of normal children (Dixon et al., 2014; Frazier et al., 2014; Jurecki et al., 2019).

Besides that, the total protein requirement of all patients with AAMDs except those with urea cycle disorders (UCD) will also be determined based on the Malaysian RNI 2017, with an additional 20-40% of the total protein for patients who consume synthetic metabolic formula (Frazier et al., 2014).

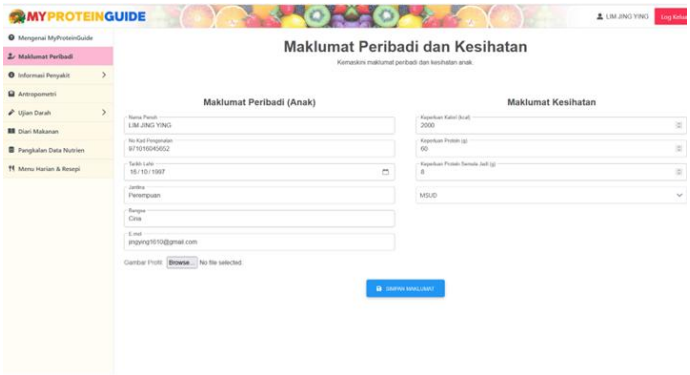

Figure 2: Personal profiles of the patients with AAMDs

Disease information

This section introduces all 10 AAMDs (Figure 3). This comprises basic information about each disorder, such as the underlying pathophysiology of the disrupted metabolic pathway, clinical signs and symptoms, and the medical nutrition therapy (MNT) for the specific AAMD.

All the information is presented in infographics for easy comprehension. The evidence-based practice for the diagnosis, evaluation, prevention, and treatment of inherited metabolic disorders is provided, as outlined in the clinical dietetics for paediatrics guideline (Dixon et al., 2014). All the information has been verified by clinical geneticists on the research team.

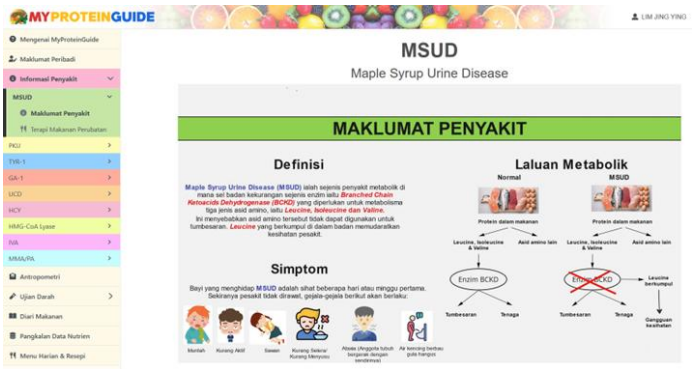

Figure 3: Diseases Information

Anthropometric measurement

This feature aims to streamline and standardise weight monitoring and growth tracking of patients with AAMDs (Figure 4). Caregivers can enter the values of body weight and height at each appointment in the genetic clinic. The interpretation of the BMI will be based on the shaded colour of the graph.

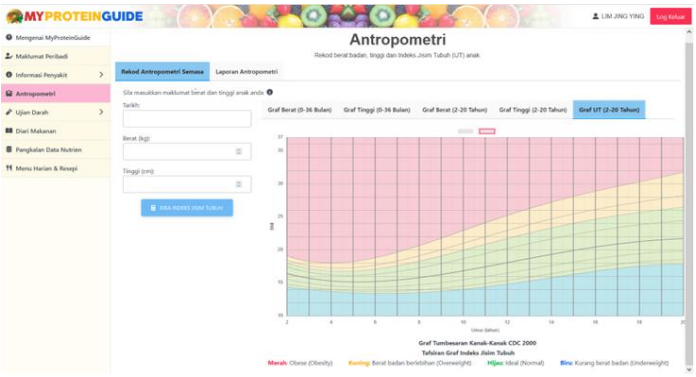

Figure 4: Anthropometric Monitoring

The 2000 Centre for Disease Control and Prevention (CDC) growth chart was used as the reference growth chart as it describes the growth of children in the United States from birth to 19 years of age. The CDC classification of growth indicators is shown in Table 1.

Table 1: Interpretation of CDC Growth Chart

BMI Percentile	Interpretation
< 5th percentile	Underweight
5th – < 85th percentile	Normal
> 85th and < 95th Percentile	At risk of overweight
> 95th percentile	Overweight

Biochemical data monitoring

This feature allows users to record their children's plasma amino acids levels in the application after each genetic clinic appointment (Figure 5). All the biochemical parameter values entered will be plotted into a graph to show the trend over time. The maximum and minimum

reference ranges for plasma amino acids will be labelled in colour on the graph.

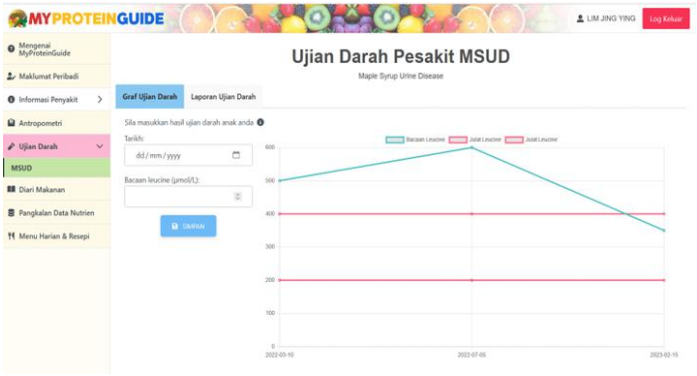

Figure 5: Biochemical Monitoring

The parameters and their reference ranges used to monitor patients with inherited metabolic disorders were determined based on clinical guidelines that have been published previously. The research team consulted with clinical geneticists and metabolic dietitians to further verify the findings. The parameter(s) used to monitor the metabolic control differ depending on the particular AAMD, as each disorder is caused by a different single enzyme deficiency that blocks a specific metabolic pathway. The specific plasma amino acids for each disorder are listed in Table 2.

Table 2: Specific plasma amino acid for monitoring

Types of AAMDs	Plasma amino acid
Maple syrup urine disease (MSUD)	Leucine
Phenylketonuria (PKU)	Phenylalanine
Tyrosinemia (TYR)	Tyrosine
Urea cycle disorders	Ammonia Glutamine Arginine
Glutaric Aciduria Type-1 (GA-1)	Lysine
Propionic Aciduria (PA)/ Methylmalonic Aciduria (MMA)	Ammonia
Isovaleric Aciduria	Isoleucine
HMG CoA Lyase	Leucine Ammonia
Homocystinuria	Homocysteine

Digital food composition database

The digital food composition database consists of 17 food groups (Figure 6). Our database excludes meat and meat products, eggs, fish and shellfish, milk and milk products as all these food items are typically inhibited in the diet (Boyer et al., 2015). In addition to that, the food composition database consists of the nutrients content of all metabolic formulas and modular formulas. The calories and macronutrients content as well as the weight (gram) and serving size of the food items are all displayed.

Figure 6: Digital food composition database

Food diary

Caregivers can use the food diary to record their children's daily intake of food and drinks, with the weight of the raw food items in grams required to be entered in the system (Figure 7). The macronutrients of each food item entered will be calculated automatically using the weight of the raw food entered and linking each food item to the digital food composition database as described previously. A bar chart will be used to track the daily number of calories, total protein, and targeted natural protein intake. The targeted natural protein is calculated by subtracting the protein from the metabolic formula from the total protein. Users can also trace their food intake for the past 30 days, which can be shared as a report with their metabolic dietitian.

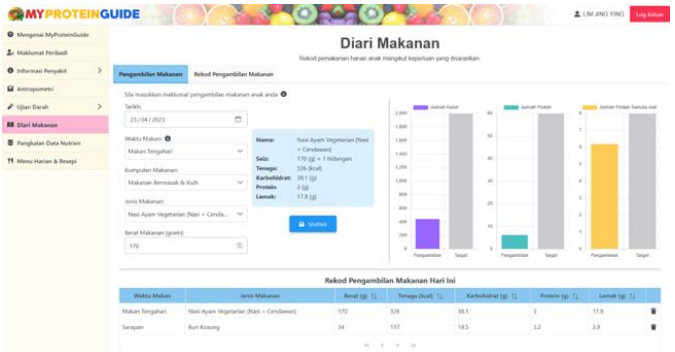

Figure 7: Food Diary

One-day Menu and Recipes

The MyProteinGuide™ application also provides examples of one-day menus (Figure 8). These menus contain low protein foods and dishes for breakfast, lunch, and dinner

which will make up a total of 5g, 8g, 10g and 12g of natural protein. These menus offer caregivers ideas about diet preparation for their children. Besides that, it also provides examples of low-protein recipes which were formulated and modified by dietitians on the research team (Figure 9). The process of recipe development was described in the next section.

Figure 8: Digital food composition database

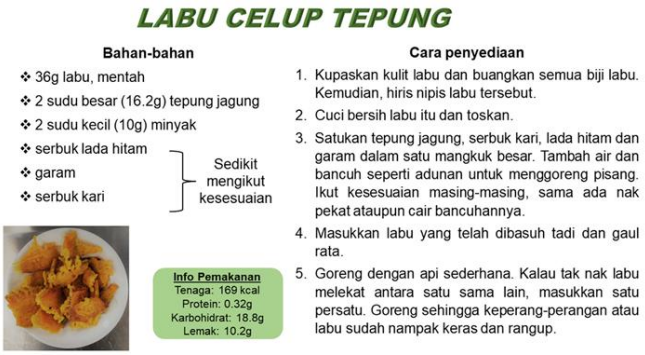

Figure 9: Example of Low Protein Recipes

Low Protein Recipes Development

After obtaining suitable recipes from recipe books or websites, the modification process was carried out by considering the individual's tolerated range of natural protein. The ingredients used in the recipe formulation were selected based on the following factors: the common low protein foods that patients consume, the amount of natural protein per serving, availability, price, cultural appropriateness, and the method of preparation.

With regard to the weaning diet recipes, they consist of 0.5-1.0g of protein per meal, while the main meal recipes consist of 2.0-3.0g for each meal. The main ingredients used in formulating low-protein recipes mostly consists of cereals, vegetables, and fruits. Snacks were modified using low protein flour and other flour products with minimal protein content, such as corn flour and tapioca flour, which are easily available and affordable. The nutritional values of all the recipes were calculated using the Nutritionist Pro™ software.

All the ingredients calculated were weighed accurately for cooking. A student researcher and other research enumerators weighed the ingredients accurately according to the calculations and then prepare and cooked the dishes in the diet therapeutic lab of the Faculty of Health Sciences, Universiti Kebangsaan Malaysia (UKM). Furthermore, three panels of clinical dietitians and academic dietitians or nutritionists who specialized in the paediatric field conducted sensory evaluation.

The recipes were evaluated for their colour, appearance, body and texture, taste and flavour and overall acceptability using a five-point hedonic scale, comprising: 1= dislike extremely, 2 = dislike moderately, 3 = neither like nor dislike, 4 = like moderately, and 5 = like extremely. A score of more than 3 indicated that the recipes were on average acceptable (Muhimbula et al., 2011). The process of recipe modification is simplified in Figure 10.

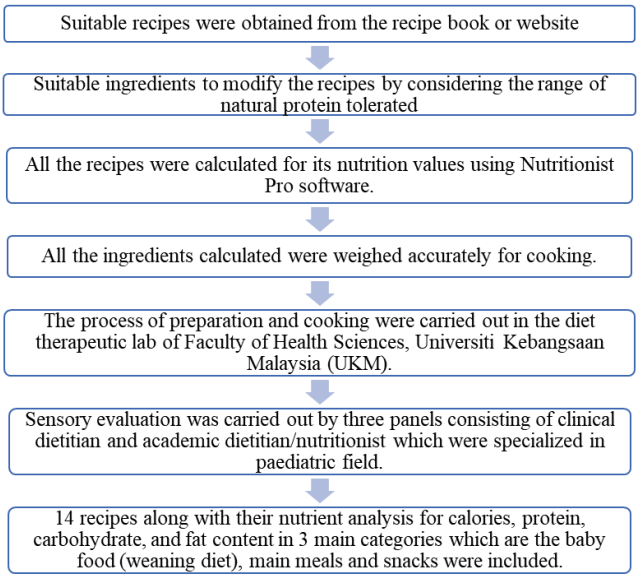

Figure 10: Flow chart illustrating the process of modifying recipes

Methodology for Validation Study

According to Yusoff (2019), the number of experts for content validation should be at least six and does not exceed 10. Hence, content validation was carried out among nine experts, including five dietitians with a minimum of one year of clinical experience in managing inherited metabolic disorders, and four consultant clinical geneticists. The evaluation considered the relevance, appropriateness, ease of use, accuracy of the language used in the features content, and attractiveness and appropriateness of the graphical user interface (GUI) based on the four-point scale (1 for "not relevant"; 2 for "some revision required"; 3 for "relevant but needs minor revision" and 4 for "very relevant"). Lastly, the content validation index (CVI) was calculated, which measures the

proportion of items on the scale that achieve a relevance scale of 3 or 4 by all experts (Yusoff, 2019).

Ethical Approval

This study was approved by the Medical Research Ethics Committee (MREC) (NMRR ID-22-00762-UKN) and the Secretariat of Research Ethics Committee, Universiti Kebangsaan Malaysia (JEPUKM-615 2021-765).

RESULTS

Evaluation of low protein recipes

All the recipes provided in this website have scored a minimum of 3 out of 5 points in term of taste, appearance, smell, mouth feel, aftertaste and general acceptability indicating good acceptability (Table 3).

Table 3: Evaluation of Low Protein Recipes

	Taste	Appearance	Smell	Mouthfeel	Aftertaste	General acceptability
Nasi Minyak + Kurma Kentang	4	4	4.3	4.7	4.3	4
Soo-Hoon Goreng	43	4.3	4.3	4.3	4.3	4.3
Laksa Goreng	3.7	3.7	4.3	4.3	4.3	4.3
Nasi Ayam Vegetarian + Cendawan Tiram Goreng	4.0	3.7	4.3	3.7	4.0	4.0
Nasi Tomato	3.0	4.0	3.7	3.0	3.0	3.0
Puding Sago Gula Melaka	5.0	5.0	4.7	5.0	5.0	5.0
Cucur Nasi	4.0	3.3	3.0	3.7	3.7	3.7
Agar-agar Laici	5.0	5.0	4.7	5.0	5.0	5.0
Labu Salut Tepung Jagung	4	4.5	4.5	4.0	4.5	4.0

Content Validation of the Module

The "Content features" of MyProteinGuide™, received a CVI of 0.982, which indicates that there was an excellent level of agreement between the experts on the content validity of the module as shown in Table 4. As the overall CVI of the module was 0.983, the module was deemed validated for content. Most experts (5/9; 56%) rated all the 6 features of MyProteinGuide™ as very relevant, while the remaining rated them as relevant but needing minor revision. Moreover, 77.8% (7/9) of experts rated the language used in MyProteinGuide™ as appropriate, easy to understand, and accurate. Lastly, 66.7% (6/9) viewed that the GUI was appropriate and attractive.

Table 4: Content validity index for MyProteinGuide™ by expert panel members (n=9)

Criteria	Item Description	I-CVI
Content Features	Disease Information	1
	Anthropometric Monitoring	1
	Biochemical Monitoring	1
	Food Diary	1
	Food Composition Database	1
	Low Protein Recipe & One-day Menu	0.889
Average CVI		0.982
Language	Appropriateness for users >18 years old	1
	Accurateness of the terms used	1
	Easiness to understand	1
Average CVI		1
Graphic User Interface (GUI)	Attractiveness of the colour scheme	0.889
	Appropriateness of the font size and easiness to read	1
	Appropriateness of the characters/ icon/logo	1
	Appropriateness of the layout (label, button, info) in each screen	1
Average CVI		0.972
Overall CVI		0.983

Overall, the healthcare professionals rated the module positively. They considered the module informative and relevant for monitoring the metabolic and health status of patients. Despite the positive feedback, some healthcare experts raised concerns regarding the content features, language used, and user interface. Table 5 summarized the suggestions made by expert panels to improve the MyProteinGuide™.

Table 5: Suggestions by expert panels to improve MyProteinGuide™

Main Topics	Descriptions
Content Features	- Standardisation of terms used in describing the metabolic pathway - Gender-labelled growth chart - Updated list of metabolic formulas and its nutrient contents - Include HBV protein food sources - Increase variety of recipes - Auto-tailored recipes for specific diseases - Include photos of food items with proper portion size in the food composition database - Inclusion of household measurements in quantifying portion size
Language	- Correction of spelling errors - Standardisation of language used
Graphic User Interface (GUI)	- Standardisation of colour picture

DISCUSSION

This study describes the development of the web-based application, MyProteinGuide™, which provides personalized content, including self-monitoring and educational features, to help caregivers of children with AAMDs effectively track their dietary habits. The key feature of this application is that it includes mostly all of the components of nutritional assessment, including client history, anthropometry, biochemical data, and dietary history monitoring, as outlined in the nutritional care process (Writing Group of the Nutrition Care Process/Standardised Language Committee, 2008). Compared to the traditional method of tracking weight changes, plasma amino acid values, and diet history in separate sheets manually, MyProteinGuide™ is more convenient for both caregivers and healthcare professionals of patients with AAMDs to pinpoint certain foods, total natural protein intake or metabolic formula consumption that may be influencing patients' plasma amino acid readings (Chen et al., 2018). A previous study developed an application that helps patients with 15 different inborn errors of metabolisms (IEMs) track the amino acid content of foods that are specific and relevant to their IEM (Ho et al., 2016). For instance, patients with maple syrup urine disease (MSUD) can track the leucine content of foods. However, our study did not include the amino acid content in our application as it is the practice in our hospital to focus on total natural protein intake only, instead of amino acid contents. In addition to that, our study was not only focused on providing dietary monitoring, but also on creating an 'all-in-one' application that includes all the components of nutritional assessment to simplify the self-monitoring process.

To the best of author's knowledge, this is the first dietary self-monitoring web-based application that was designed specifically for caregivers of patients with AAMDs using a user-centred approach, involving discussions with users from the early stages of development. Considering the heterogeneous nature of AAMDs, it is essential to individualise and prioritize user needs to the specific needs and profiles of each caregiver to enable more appropriate web design and ensure effective outcomes (Gabrielli et al., 2017). One of the highlights of the MyProteinGuide™ web-based application is the incorporation of individualised energy and total natural protein requirements with automated calculation of dietary intake progress using real-time data interpretation feature (Ahn et al., 2019). By reducing the burden of food preparation, this features provides more time and energy of caregivers, which can then be used to support the person with dietary self-management (Quesada-Lopez et al., 2016). Besides that, to accommodate the needs of diverse users and provide personalized content, the one-day menu included different amounts of protein and low-protein recipes suitable for different age groups. Unlike previous studies, which did not evaluate the specific recipes included in their application (Ramanathan et al., 2013; Salihah et al., 2017), our study conducted food sensory testing on the modified low-protein recipes among the healthcare providers to validate its suitability for patients with AAMDs. Interestingly, the food sensory test was not conducted with the actual patients with AAMDs due to practical and ethical considerations as most of the patients were aged below 12 years old. This approach had been used in preliminary recipe development in which thehealthcare professionals had tasted the end products to determine the acceptability of these modified recipes among the target population (Ettinger et al., 2014).

In addition, the features of MyProteinGuide™ were specifically designedbased on data collected from the FGDs during the requirements analysis stage. In the context of our study, AAMDs are a group of chronic disease in which it is essential to adhere to a specific amount of natural protein in the diet to ensure the patients' plasma amino acids are maintained within a normal range that does not cause neurotoxicity. Adequate calorie intake is also important to prevent catabolism and maintain a normal body weight, which can improve and maintain quality of life (Boyer et al., 2015; Frazier et al., 2014). As such, all of the features in this application were designed to address the challenges that caregivers face when assessing the needs of patients with AAMDs (Lim et al.,

2022), ultimately, leading to successful dietary treatment and adherence.

All the expert panels involved in this study agreed that the content validity index (CVI) of MyProteinGuide™ was rated as appropriate. The healthcare professionals also found many positive features about the application's components and functionalities. However, a deeper analysis of the healthcare experts' feedback on the content features of the MyProteinGuide™ indicated that providing additional support for defining food quantities using household measurements instead of using weight would ease the dietary monitoring process. Another suggestion for improving the application was to add high biological value (HBV) protein sources such as chicken, fish, egg and their products, however, this may be controversial among the healthcare providers. The allowance for natural protein varies among different types of AAMDs. Some patients with a higher allowance for natural protein are allowed take the HBV protein. To accommodate this discrepancy, more advanced settings should be included to enable users to customize the food database, menus, and recipes to their specific type of AAMDs. Nevertheless, this type of automatically generated tailored information to the existing application would require greater expert technological knowledge and skills, more time, and extensive financial resources (Simons et al., 2018).

The key strength of this study is the involvement of caregivers of patients with AAMDs and healthcare practitioners in the app development process, which allowed the app to be tailored to the needs and preferences of caregivers. The development of MyProteinGuide™ was a structured process that involved collecting qualitative data from caregivers of children with AAMDs in Malaysia. The modules were then developed based on this data, and the application was adapted to the specific needs of these Malaysian caregivers in several ways, such as using simple Malay language, providing ample white space for easy navigation, and tailoring the content to the cultural preferences of Malaysians by including a variety choice of recipes using local products and their nutrient analysis based on the Malaysian food composition database.

There are several limitations in this study. Firstly, some app features could not be implemented due to limited time and financial resources, even though they were of interest to the target group. These features included highly personalized advice tailored to the health status, in-app notifications as a reminder, and a social forum for caregivers to communicate with each other. Future versions of the app may need to include these features. Next, the choice to develop a web-based application instead of a mobile-friendly (responsive) version may limit its usability and for self-monitoring. In addition to that, MyProteinGuide™ is specifically adapted to the Malaysian population, which limits its generalizability to other populations. Hence, it is suggested to translate it into other languages and adapt the content, such as the ingredients used in the recipes, to make it more accessible to other target groups worldwide.

CONCLUSION

MyProteinGuide™ has the potential to become an effective solution for supporting self-monitoring of nutritional status and delivering nutrition education for caregivers with children with AAMDs. The user-centred design and evidence-based approach used to design the application which combines setting individualised energy and protein prescription, nutritional status monitoring and educational components such as low protein recipes, represents a significant advance over the functionality of current available commercial application for patients with AAMDs. Future refinements of the application should be taken into account and addressed accordingly to optimize its use among caregivers of patients with AAMDs.

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ORIGINAL ARTICLE

The Prevalence of Knee Pain and Associated Risk Factors in Malaysian Long-Distance Runners

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ABSTRACT

Background: Running is one of the most popular and accessible sports worldwide. Despite its accessibility, running may increase the likelihood of musculoskeletal disorders such as knee pain. There is a paucity of evidence regarding knee pain among long-distance runners in Malaysia. Therefore, this study aimed to determine the prevalence of knee pain and its associated risk factors among long-distance runners in Malaysia. **Methods:** A cross-sectional study was conducted using the Running-related Injury (RRI), the Oslo Sports Trauma Research Centre (OSTRC) Overuse Injury, and the Kujala Anterior Knee Pain Scale (AKPS) questionnaires. The questionnaires were distributed to Malaysian runners through social media platforms using Google Forms. Data were analysed using the Chi-square test and independent t-test. **Results:** A total of 66 runners completed the study. Approximately 69.7% of runners experienced knee pain, with half-marathon runners being the most common group to report such discomfort. No significant association was observed between any potential risk factors - such as gender, body mass index (BMI), and running experience - and the occurrence of knee pain ($p > 0.05$). **Conclusion:** Although no significant association was found between gender, BMI, running experience, and knee pain, a high prevalence of knee pain was observed among long-distance runners. This suggests that knee pain among these runners may be influenced by multifactorial elements beyond the examined demographic and training variables. However, the relatively small sample size may have limited the statistical power to detect true associations. Future studies with larger, more representative samples are recommended to strengthen the evidence.

INTRODUCTION

Running stands out as one of the most popular and accessible sports worldwide. It has been shown to provide significant cardiovascular and metabolic benefits (Kutac et al., 2023). Despite these advantages, running may elevate the risk of various musculoskeletal injuries, particularly knee injuries (Kakouris et al., 2021).

A previous study reported that approximately 90% of 200 recreational half-marathon runners in South Africa experienced musculoskeletal injuries, with knee injuries being the most prevalent (26%) (Ellapen et al., 2013). This finding is consistent with a systematic review that identified the knee as the most frequently injured site and the joint with the highest injury prevalence among runners (Kakouris et al., 2021). These results are likely related to the propulsion generated primarily by the lower limbs during running, which imposes increased biomechanical loads on these structures (Kakouris et al., 2021).

A growing body of literature has identified intrinsic characteristics such as gender and age, as well as extrinsic factors such as running frequency and distance, as contributors to knee pain (Buist et al., 2010; Kakouris et al., 2021; Linton & Valentin, 2018). Runners experiencing knee pain often face a progressive loss of function and a reduction in health-related quality of life (Bindawas et al., 2015).

Although running is a popular sport among Malaysians, limited research has explored the relationship between running and knee pain in this population. Therefore, this study aims to determine the prevalence of knee pain among Malaysian long-distance runners, its associated risk factors, and its impact on their knee function.

MATERIALS AND METHODS

A cross-sectional study design was employed. Malaysian long-distance runners were recruited using convenience sampling. As there was no prior research reporting the prevalence of knee pain and its associated factors in Malaysia, the G*Power 3 software was used to calculate the sample size. Based on the G*Power analysis, with an effect size of 0.4, a sample of 70 participants would

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provide 95% power at a type 1 error of 0.05 using a t-test. The inclusion criteria were as follows: (1) Malaysian runners with at least one year of running experience, (2) aged between 19 and 70 years, (3) voluntary participation, and (4) ability to understand the English language. Runners who ran less than one kilometre (short-distance runners) were excluded.

The questionnaires were distributed to Malaysian runners via social media platforms such as Facebook and WhatsApp using Google Forms.

Participants were required to complete demographic information, including age, gender, state of residence, weight, height, and running history. Subsequently, they completed the Running-related Injury (RRI) questionnaire. The RRI questionnaire, consisting of 10 items, was used to analyse predictive factors of knee pain such as training frequency, weekly running distance, and stretching routine (Hsu et al., 2020).

Participants also completed the Oslo Sports Trauma Research Centre (OSTRC) Overuse Injury questionnaires, to monitor knee pain and assess the impact of overuse injuries on running participation and performance (Kaewkul et al., 2021). Each question was scored from 0 (no problems) to 25 (maximum difficulty). The scoring scale varied depending on the number of response options: 0–6–13–19–25 for five-choice questions and 0–8–17–25 for four-choice questions (Clarsen et al., 2013; Kaewkul et al., 2021). Total scores were then categorised as mild pain (1–25 points), moderate pain (26–50 points), and severe pain (51–75 points).

In addition, participants responded to selected items from the Kujala Anterior Knee Pain Scale (AKPS) to avoid redundancy and reduce response time. The items assessed activities such as walking, stair climbing, squatting, running, jumping, swelling, abnormal kneecap movement, and flexion deficiency (da Silva-Junior et al., 2024). The total score ranged from 0 to 65, with higher scores indicating better knee function. Scores were categorised as poor (≤20 points), fair (21–40 points), good (41–60 points), and excellent (≥61 points). Ethical approval for this study was obtained from the institutional Research Ethics Committee (ID number: KAHS 97/22).

Data were analysed using the Statistical Package for the Social Sciences (SPSS) version 26 for macOS. Descriptive statistics were used to summarise participants' demographic characteristics, running history, and severity of knee pain in terms of frequencies and percentages. The association between knee pain and training frequency was examined using an independent t-test, while the Chi-square test was employed to determine the association between runner categories and other potential risk factors with the occurrence of knee pain.

RESULTS

Characteristics of Participants

A total of 70 participants voluntarily took part in this survey. However, only 66 respondents met the inclusion criteria and were included in the analysis. Table 1 presents the characteristics of the participants. The study population comprised 80.3% males and 19.7% females. Participants consisted of 22 young adults (aged 19-24), 18 adults (aged 25-44), and 26 middle-aged adults (aged 45-64). Respondents from 10 out of 14 states participated in this study, with the majority from Selangor (51.5%). Among the runners, 9.0% had 4 to 10 years of running experience, while the remaining 6.0% had more than 10 years of running experience. Participants were categorised into five groups based on the type of race they had participated in, with the majority running less than 10 km (31.8%), followed by half-marathon (~21 km) runners (30.3%).

Table 1: Demographic data (n = 66)

Variable	n (%)
Gender:	
Male	53 (80.3)
Female	13 (19.7)
Age Classes:	
Young adult	22 (33.3)
Adult	18 (27.3)
Middle-aged adult	26 (39.4)
State:	
Selangor	34 (51.5)
Kedah	5 (7.6)
Perak	5 (7.6)
Negeri Sembilan	5 (7.6)
Pahang	3 (4.5)
Johor	2 (3.0)
Pulau Pinang	2 (3.0)
Terengganu	1 (1.5)
Kelantan	1 (1.5)
Wilayah Persekutuan, Putrajaya, and Kuala Lumpur	8 (12.1)
Running Experience:	
1-3 years	15 (22.7)
4-10 years	41 (62.1)
More than 10 years	10 (15.2)
Groups of Runners:	
< 10 km	21 (31.8)
10 km	6 (9.1)
Between 10 and 21 km	7 (10.6)
Half marathon (~21 km)	20 (30.3)
Marathon (~42 km)	12 (18.2)

Prevalence of Knee Pain

A total of 46 runners (69.7%) reported having experienced knee pain related to running, while the remaining 20 runners (30.3%) reported no knee pain. Among participants who ran less than 10 km, 11 runners (52.4%) experienced knee pain, while 10 runners (47.6%) did not. All 10 km runners reported knee pain, with a frequency of 6. For runners covering distances between 10 km and 21 km (less than a half-marathon distance), 5 runners (71.4%) experienced knee pain, while the remaining 2 runners (28.6%) did not. Among half-marathon runners, 16 runners (80%) reported knee pain, whereas among marathon runners, 8 runners (66.7%) experienced knee pain. In each group, the remaining participants—4 half-marathon runners (20%) and 4 marathon runners (33.3%)—did not report knee pain.

Knee Pain and its Associated Risk Factors

Based on Table 2, this study found that 73.6% of male runners developed knee pain, whereas the rate among female runners was 53.8%. The highest prevalence of knee pain was observed among middle-aged adults (80.8%), followed by young adults (63.6%) and adults (61.1%). Among overweight runners, 81.5% reported knee pain, which was higher compared to other BMI categories. Notably, all three runners classified as underweight also reported experiencing knee pain.

Runners with 4 to 10 years of running experience had the highest occurrence of knee pain (70.7%). In contrast, 60% of those with less than 3 years of experience and 80% of those with more than 10 years of experience reported knee pain.

Although stretching is commonly regarded as a preventive measure against injuries, Table 2 shows that 76.3% of runners developed knee pain despite always stretching before running. Similarly, 67.7% of runners who consistently stretched after running also reported knee pain. Among the participants, 55 runners engaged in other sports, of whom 36 (65.5%) experienced knee pain, while the rest did not. Interestingly, among the 11 runners who did not participate in other sports, 10 (90.9%) reported knee pain.

This study also found that runners with a weekly running distance of 1–10 km had a higher risk of knee pain compared to those running more than 20 km per week. Of the four runners who ran 31–40 km weekly, half experienced knee pain. Surprisingly, the one runner who trained more than 50 km per week did not report knee pain. As shown in Table 2, no statistically significant association was found between knee pain and any of the associated factors mentioned above ($p > 0.05$).

Table 2: Associated Factors of Knee Pain

Variables	Knee Pain		Total	*p*-value
	Yes (%)	No (%)	n (%)	
Gender				
Male	39 (73.6)	14 (26.4)	53 (100)	0.190
Female	7 (53.8)	6 (46.2)	13 (100)	
Age				
Young adult	14 (63.6)	8 (36.4)	22 (100)	0.277
Adult	11 (61.1)	7 (38.9)	18 (100)	
Middle-aged	21 (80.8)	5 (19.2)	26 (100)	
BMI				
Underweight	3 (100)	0	3 (100)	
Normal	18 (56.3)	14 (43.8)	32 (100)	
Overweight	22 (81.5)	5 (18.5)	27 (100)	0.052
Obesity (C1)	3 (100)	0	3 (100)	
Obesity (C2)	0	1 (100)	1 (100)	
Running experience				
1-3 years	9 (60)	6 (40)	15 (100)	
4-10 years	29 (70.7)	12 (29.3)	41 (100)	0.549
> 10 years	8 (80)	2 (20)	10 (100)	
Stretching (Before)				
Always	29 (76.3)	9 (23.7)	38 (100)	
Sometimes	16 (64)	9 (36)	25 (100)	0.196
Never	1 (33.3)	2 (66.7)	3 (100)	
Stretching (After)				
Always	21 (67.7)	10 (32.3)	31 (100)	
Sometimes	20 (74.1)	7 (25.9)	27 (100)	0.805
Never	5 (62.5)	3 (37.5)	8 (100)	
Involvement in other sports				
Yes	36 (65.5)	19 (34.5)	55 (100)	0.152
No	10 (90.9)	1 (9.1)	11 (100)	
Weekly running distance				
1-10 Km	17 (65.4)	9 (34.6)	26 (100)	
11-20 Km	14 (73.7)	5 (26.3)	19 (100)	
21-30 Km	10 (83.3)	2 (16.7)	12 (100)	0.500
31-40 Km	2 (50)	2 (50)	4 (100)	
41-50 Km	3 (75)	1 (25)	4 (100)	
51-60 Km	0	1 (100)	1 (100)	

The means of runners experiencing knee pain and those without knee pain were compared based on training frequency using an independent sample t-test. No significant relationship was found between training frequency and the knee pain among runners ($p = 0.472$).

Scoring of Knee Function

The 46 runners who had experienced knee pain due to running were further classified according to the severity of their pain based on the OSTRC Overuse Injury Questionnaire. The results showed that 21 runners (45.7%) reported mild pain, 23 (50%) reported moderate pain, and only 2 runners (4.3%) experienced severe knee pain.

Concerning knee function, only one runner with knee pain received a fair knee function score. Despite experiencing knee pain, 33 runners achieved good knee function scores, while 12 runners attained excellent scores, representing 100% and 37.5%, respectively.

DISCUSSION

The findings of this study revealed a high prevalence of knee pain among runners, consistent with previous articles identifying the knee as the most frequently injured anatomical region in this population (Kakouris et al., 2021; Van Gent et al., 2007). Moreover, overuse injuries have been reported to account for approximately 60.6% of all running-related injuries, with patellofemoral pain syndrome and iliotibial band syndrome being the most common knee conditions resulting from excessive repetitive running and jumping (Sanfilippo et al., 2021).

It is postulated that runners experience a high prevalence of knee pain due to repetitive submaximal strain and/or insufficient tissue recovery (Gizinska et al., 2025; Mellinger & Neurohr, 2019). This hypothesis aligns with the findings of the present study, suggesting that many runners may have experienced overuse injuries, possibly due to their training regimens involving longer training runs. Consistently, a study on runners preparing for a half-marathon race reported that 37.3% of participants experienced health issues, with overuse injuries accounting for the greatest burden (18%) (Hollander et al., 2018).

Conversely, anatomical malalignment of the lower extremities including femoral neck anteversion, genu valgum, knee hyperextension, and excessive rearfoot pronation, together with muscular imbalance or weakness, particularly of the quadriceps and poor running mechanics, may further contribute to the development of knee pain (Mellinger & Neurohr, 2019).

This study also found that the number of runners with knee pain was higher among males compared to females. However, this finding is not conclusive, as there was a large gender imbalance among participants. Furthermore, the study demonstrated no significant association between gender and knee pain. According to Buist et al. (2010), male runners are influenced by factors such as BMI, previous musculoskeletal injuries of the lower limbs or back, and running experience, whereas female runners are more commonly associated with no prior running experience. Collectively, these findings suggest that the predictors of knee pain differ between male and female runners (Buist et al., 2010; Hootman et al., 2002).

This study also observed that middle-aged adults constituted the group with the highest prevalence of knee pain, aligning with previous studies (Naderi et al., 2024; Nielsen et al., 2013; Satterthwaite et al., 1999). This may be attributed to age-related degeneration, in which the joint deteriorates due to repeated impact and loading on the articular cartilage. However, this finding contradicts a previous study that reported runners with lower age had a higher risk of injury (Rasmussen et al., 2013). Differences in running experience may help explain the conflicting results regarding age and injury risk. The present study showed that runners with more than 10 years of running experience were the least likely to develop knee pain. This may be because experienced runners have developed musculoskeletal adaptations that reduce their susceptibility to injury and are likely better at recognising their body's signals and adjusting their training accordingly to prevent injuries.

This study found that overweight runners were the most likely to experience knee pain. This occurrence is likely related to the kinetics and kinematics of the knee joint during running. Obese runners were shown to generate ground reaction force impulses that were 40.2% greater than those of non-obese runners, ultimately increasing joint loading, especially at the knee (Vincent et al., 2020). Additionally, carrying external weight equivalent to 10–30% of body mass has been shown to increase leg stiffness by 2.8–25.7%, leading to greater loading on the lower limbs (Vincent et al., 2020). To cope with this additional load, the body automatically stiffens the leg through increased muscle co-contraction to stabilise the limb and control impact. However, this adaptation results in excessive biomechanical stress, which can adversely affect the knee.

Generally, it is widely believed that stretching helps prevent sports-related injuries. Exercises that include stretching have been shown to reduce the risk of knee pain by improving the flexibility of the muscle–tendon unit (Coppack et al., 2011). Nevertheless, the present study found that most of the runners who experienced knee pain performed stretching both before and after running. This result is aligned with previous systematic reviews This finding aligns with previous systematic reviews reporting that stretching has no significant association with injury prevention (Almaawi et al., 2020; Thacker et al., 2004). However, stretching may still enhance running performance by improving muscle and joint flexibility.

This study found that runners who ran less than 20 km per week were more likely to sustain knee injuries than those who ran more than 20 km per week. This result is

supported by another study, which reported that runners with a weekly training volume below 30 km had a 2.34 times higher relative risk of injury (Rasmussen et al., 2013). It is postulated that lower training loads may lead to weaker active and passive stabilisers of the patellofemoral complex (Hreljac, 2004), thereby increasing the risk of patellofemoral pain syndrome among runners. Furthermore, running experience may also play a contributing role in this relationship.

Although the runners reported knee pain, most achieved good functional scores, indicating that their activity limitations were not severe. Half-marathon runners constituted the group with the highest proportion of good scores compared to other categories. This could be attributed to their adaptation to pain when performing mobility or knee-related exercises. Only one runner reported that most activities involving the knee were painful and limited, which may be due to a lack of knowledge about pain management. Notably, eight out of twelve marathon runners achieved excellent functional scores, potentially reflecting greater running experience and accumulated knowledge related to injury management and symptom control.

However, the observation that more experienced runners reported lower levels of knee pain should be interpreted with caution. While musculoskeletal adaptation associated with prolonged training may partly explain this pattern, it may also reflect survivor bias, whereby runners who experience persistent or severe knee pain reduce their training load or discontinue running altogether. Consequently, the remaining sample may represent a healthier subset of runners, leading to an underestimation of knee pain severity among long-distance runners.

Study Strengths and Limitations

This study is limited by convenience sampling, a small sample size (n = 66), and a marked gender imbalance (80.3% male), which may restrict generalisability. The use of selected items from the Kujala Anterior Knee Pain Scale may have compromised outcome validity and limited comparability with studies using the full instrument. Statistically, violations of Chi-square assumptions, lack of adjustment for multiple comparisons, and limited power may have affected the reliability of the findings. Future studies should recruit larger samples and apply more robust analytical approaches.

Despite these limitations, this study has notable strengths, including addressing a significant gap in the regional sports medicine literature by providing preliminary evidence on this under-researched population.

CONCLUSION

It can be concluded that the prevalence of knee pain among selected Malaysian long-distance runners is high. Although no significant association was found between gender, BMI, running experience, and the occurrence of knee pain, this suggests that knee pain among these runners may be influenced by multifactorial elements beyond the examined demographic and training variables. Additionally, the impact of knee pain on functional performance was generally mild. While this preliminary study found a high prevalence of knee pain, the small sample size limited our ability to detect significant associations with potential risk factors. The findings suggest that knee pain is multifactorial, and future, larger-scale studies are needed to reliably identify contributing factors in this population.

CONTRIBUTION TO THE ADVANCEMENT OF KNOWLEDGE

At this stage, the primary contribution of this study is to highlight the extent of the problem and underscore the need for more robust research in this population. As a pilot investigation, the findings may inform the design and methodological considerations of future, larger-scale studies.

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DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used ChatGPT to identify and correct grammatical errors, as well as to suggest improvements for clarity and conciseness. The authors subsequently reviewed, revised, and approved all content, and accept full responsibility for the final manuscript.

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ORIGINAL ARTICLE

Challenges and Attitudes to Practising Primary Eye Care Among Malaysian Private Optometrists: Findings from the CAPEC Questionnaire

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ABSTRACT

Background: Primary Eye Care (PEC) is an essential component of preventive eye health, yet its implementation in Malaysia's private optometry sector remains limited. Building upon a previously validated instrument (CAPEC questionnaire), this study aimed to assess the current challenges and attitudes of private optometrists towards practising PEC, and to identify factors associated with these domains. **Methods:** A cross-sectional online survey was conducted among optometrists practising in Malaysian private settings from May to October 2021. Respondents completed the validated Challenges and Attitudes to Practice Primary Eye Care (CAPEC) questionnaire, consisting of 34 items across six domains: four domains of *challenges* (working environment, support and recognition, self-sufficiency, and customer influence) and two domains of *attitudes* (motivation and sense of responsibility). Descriptive statistics, MANOVA, and multiple linear regression were used to explore domain differences and associations between challenges and attitudes. **Results:** A total of 291 optometrists participated. Among the challenge domains, *support and recognition* recorded the highest mean score (M = 3.57, SD = 0.53), indicating substantial barriers due to limited institutional acknowledgement and professional recognition. Attitudes toward PEC were generally high, particularly for *sense of responsibility* (M = 4.58, SD = 0.42). Factorial MANOVA revealed that practice ownership significantly influenced perceived challenges (p = 0.027), where practice owners reported higher barriers in *support and recognition*. Multiple linear regression analysis demonstrated that *support and recognition*, *self-sufficiency*, and *customer influence* significantly predicted the overall attitudes toward implementing PEC (p < 0.001). **Conclusion:** Despite facing considerable challenges, Malaysian private-sector optometrists exhibit strong motivation and a high sense of responsibility towards PEC. Strengthening institutional support, recognition frameworks, and continuing professional development opportunities could accelerate PEC adoption in private practices, ultimately enhancing nationwide eye care accessibility.

INTRODUCTION

Primary Eye Care (PEC) is a cornerstone of eye health systems, aimed at providing early detection, prevention, and management of ocular diseases at the community level. The World Health Organization (WHO) has emphasised the integration of PEC into primary health frameworks as a global strategy to reduce avoidable visual impairment and blindness (WHO, 2019). In Malaysia, however, the delivery of PEC remains largely concentrated within the public sector, with optometrists in private practice still underutilised despite their capacity and qualifications to perform comprehensive eye care services (Abd Aziz et al., 2020; Chew et al., 2018).

Previous studies indicated that the private optometry sector in Malaysia continues to focus primarily on refractive and dispensing services, with limited provision of comprehensive PEC activities such as ocular health screening, diabetic eye care, and glaucoma detection (Mohidin & Hashim, 2011; Taub, 2015). This underutilisation contributes to the overburdening of tertiary eye clinics and longer waiting times for patients in the public health system (Keat & Keat, 2009). The integration of PEC in private practices, therefore, has the potential to enhance eye care accessibility and strengthen public–private collaboration in achieving universal eye health coverage.

In a prior qualitative study, four major challenges were identified that hinder PEC implementation among private optometrists in Malaysia: working environment**,** support and recognition**,** self-sufficiency**,** and customer influence (Yahaya et al., 2023). While these findings provided essential contextual understanding, there remained a lack of quantitative data to estimate the prevalence and extent

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of these barriers. Subsequently, the Challenges and Attitudes to Practice Primary Eye Care (CAPEC) questionnaire was developed and validated as a psychometrically sound instrument to quantitatively assess these constructs (Yahaya & Rahman, 2024). The CAPEC tool encompasses six domains — four for challenges (*working environment*, *support and recognition*, *self-sufficiency*, and *customer influence*) and two for attitudes (*motivation* and *sense of responsibility*).

Attitudinal factors, particularly professional motivation and perceived responsibility, are critical in determining whether optometrists are ready to incorporate PEC into their clinical routines. According to behaviour change frameworks, attitudes interact closely with environmental and institutional barriers, influencing the likelihood of adopting new clinical practices (Ajzen, 1991; Fishbein & Ajzen, 2010). Therefore, assessing both challenges and attitudes concurrently provides a more holistic understanding of PEC implementation readiness in the private sector.

This study serves as a continuation of the previous CAPEC validation phase and reports national-level results obtained using the validated questionnaire among Malaysian private-sector optometrists. Specifically, it seeks to:

1. Determine the prevalence and relative magnitude of challenges and attitudes toward implementing PEC;
2. Examine subgroup differences based on demographic and professional characteristics; and
3. Explore associations between the identified challenges and attitudes toward practising PEC.

Through this analysis, the study aims to provide evidence-based insights for policymakers, professional bodies, and educators to design targeted interventions and capacity-building strategies that facilitate the integration of PEC within private optometry practice in Malaysia.

MATERIALS AND METHODS

Study Design and Setting

This study employed a cross-sectional quantitative design, forming the third phase of a mixed-methods research project on PEC practice among optometrists in Malaysia. Data collection was conducted through an online survey using a Google Forms link distributed between May and October 2021. The survey targeted registered optometrists working in private optometry practices across Malaysia. Ethical approval for this study was obtained from the International Islamic University Malaysia Research Ethics Committee (IIUM IREC) (ID: IREC 153/20).

Participants and Recruitment

Eligible participants were optometrists currently practising in private optometry settings, including independent, group, and retail-chain practices. The inclusion criteria were:
(a) registered with the Malaysian Optical Council (MOC);
(b) having at least one year of working experience in private practice; and
(c) consented voluntarily to participate.
Optometrists practising in hospitals, refractive surgery centres, or academic institutions were excluded. Recruitment was conducted via professional networks, including the *Association of Malaysian Optometrists (AMO)* and social media groups for practising optometrists. Participation was anonymous, and no personal identifiers were collected.

A total of 291 valid responses were obtained after data screening for completeness. This sample exceeded the minimum requirement for factor analysis and multivariate testing, which was calculated using GPower (effect size $f^2 = 0.15$, $\alpha = 0.05$, power = 0.80), requiring at least 150 participants.

Instrument

Data were collected using the CAPEC questionnaire — a validated instrument specifically designed to assess barriers and attitudes toward PEC among Malaysian optometrists. The CAPEC consists of 34 items across six domains:

- *Challenges:* Working Environment (5 items), Support and Recognition (8 items), Self-sufficiency (7 items), and Customer Influence (7 items).
- *Attitudes:* Motivation (4 items) and Sense of Responsibility (3 items).

Each item was rated on a five-point Likert scale ranging from *1 (strongly disagree)* to *5 (strongly agree)*. Higher scores indicate greater perceived challenges or stronger positive attitudes, depending on the domain. Domain-level mean scores were computed by averaging item responses.

In addition, the questionnaire included demographic variables such as age, gender, years in practice, type of practice, ownership status, practice location (urban/suburban/rural), and average patient load. Internal

consistency reliability (Cronbach's α) for all domains exceeded 0.70 in the validation study, confirming robust psychometric properties.

Data Collection Procedure

The questionnaire link was disseminated electronically with an invitation note explaining the study objectives and estimated completion time. Respondents were informed that participation was voluntary and that they could withdraw at any point. Data were automatically recorded in Google Sheets and exported into SPSS version 27.0 (IBM Corp., Armonk, NY, USA) for analysis. All responses were checked for missing values and outliers prior to analysis.

Statistical Analysis

Descriptive statistics (means, standard deviations, and frequencies) were used to summarise participant characteristics and CAPEC domain scores.

- Normality of data was verified using the Kolmogorov–Smirnov test.
- MANOVA and Factorial MANOVA were applied to compare domain mean scores across subgroups (e.g., practice type, ownership, years in practice).
- Simple and Multiple Linear Regression (MLR) analyses were used to examine associations between the *challenge* domains and *attitude* domains.

A significance level of $p < 0.05$ was used throughout. Results were presented as mean ± SD (standard deviation), estimated marginal means (EMM), and 95% confidence intervals (CI).

RESULTS

Participant Characteristics

A total of 291 optometrists practising in the Malaysian private sector completed the CAPEC questionnaire. Table 1 presents their demographic and professional characteristics. The majority were female (79.7%), with a mean age of 30.8 ± 6.5 years. Over half had ≤ 5 years of experience, and most worked as staff optometrists (72.9%) rather than practice owners. A large proportion were from independent practices (65.6%), with the remainder attached to chain or group practices. Most participants graduated from public universities (IPTA, 68%) and practised in suburban or non-capital locations (52.2%). These data represent a wide distribution of experience and practice settings across Malaysia.

Table 1: Socio-demographic and practice characteristics of participants (n = 291)

Variable	Category	n (%)
Gender	Male	59 (20.3)
	Female	232 (79.7)
Years in practice	≤ 5 years	171 (58.8)
	6 – 10 years	82 (28.2)
	> 10 years	38 (13.1)
Ownership	Owner	79 (27.1)
	Staff	212 (72.9)
Type of practice	Independent	191 (65.6)
	Chain/Group	100 (34.4)
Location	Capital / Urban	139 (47.8)
	Non-capital / Suburban-rural	152 (52.2)
Graduating university	IPTA	198 (68.0)
	IPTS	93 (32.0)
Ethnicity	Bumiputera	215 (73.4)
	Non-Bumiputera	76 (26.6)

Note. IPTA = public university; IPTS = private university.

CAPEC Domain Scores

The descriptive statistics for the CAPEC domains are summarised in Table 2. Among the four *challenge* domains, Support and Recognition recorded the highest mean (M = 3.57, SD = 0.53), reflecting substantial perceived barriers due to limited professional acknowledgment and institutional backing for PEC activities. This was followed by Working Environment (M = 3.41, SD = 0.52), Self-Sufficiency (M = 3.36, SD = 0.48), and Customer Influence (M = 3.31, SD = 0.50). Despite these challenges, optometrists demonstrated strong *attitudes* toward PEC, with high mean scores in both Motivation (M = 4.45, SD = 0.44) and Sense of Responsibility (M = 4.58, SD = 0.42). Cronbach's alpha coefficients ranged from 0.71 to 0.82, indicating satisfactory internal reliability for all domains.

Table 2: CAPEC Domain Scores Among Malaysian Private Optometrists (n = 291)

Domain	No. of items	Mean ± SD	95 % CI	Cronbach's α
Challenges				
Working Environment	5	3.41 ± 0.52	(3.35 – 3.47)	0.80
Support & Recognition	8	3.57 ± 0.53	(3.49 – 3.65)	0.80

Domain	No. of items	Mean ± SD	95 % CI	Cronbach's α
Self-Sufficiency	5	3.36 ± 0.48	(3.30 – 3.42)	0.73
Customer Influence	4	3.31 ± 0.50	(3.25 – 3.37)	0.71
Attitudes				
Motivation	7	4.45 ± 0.44	(4.39 – 4.51)	0.75
Sense of Responsibility	5	4.58 ± 0.42	(4.52 – 4.64)	0.82

Note. Scored on a 1–5 Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).
Abbreviations: SD= standard deviation; CI= confidence interval

Subgroup Differences

Analysis using Factorial MANOVA revealed significant differences across selected subgroups (Table 3). Practice ownership was a significant factor affecting the *Support and Recognition* domain (F = 4.93, p = 0.027), with owners reporting higher perceived challenges than employed optometrists (EMM = 3.72, 95% CI = 3.58–3.86 vs. 3.47, 95% CI = 3.36–3.47). A marginal difference was also noted for *Self-Sufficiency* across type of practice, where independent practitioners reported slightly higher self-perceived competency levels than those in chain or group settings (F = 3.84, p = 0.048). No other demographic variables demonstrated statistically significant effects.

Associations Between Challenges and Attitudes

Simple and MLR analyses were conducted to explore the predictors of positive attitudes toward PEC. The final multiple regression model (Table 3) revealed that Support and Recognition (β = 0.34, p < 0.001), Self-Sufficiency (β = 0.22, p < 0.001), and Customer Influence (β = 0.29, p < 0.001) were significant predictors of optometrists' overall attitudes toward PEC practice. The model explained 43% of the variance (adjusted R^2 = 0.43) in attitude scores. These results suggest that optometrists who feel more supported institutionally, possess greater self-confidence in their skills, and encounter cooperative patient attitudes are more motivated and responsible in adopting PEC services.

Table 3: Summary of Significant Subgroup Differences and Associations (MANOVA & Regression Analyses)

Factor / Variable	Domain affected	Statistical test	Statistic (F / β)	p-value	Direction of effect
Practice ownership	Support & Recognition	Factorial MANOVA	F = 4.93	0.027	Owners > Staff
Type of practice	Self-Sufficiency	MANOVA	F = 3.84	0.048	Independent > Chain
Customer Influence → Attitudes	Motivation	MLR	β = 0.29 (95 % CI 0.15–0.43)	< 0.001	Positive
Support & Recognition → Attitudes	Sense of Responsibility	MLR	β = 0.34 (95 % CI 0.21–0.47)	< 0.001	Positive
Self-Sufficiency → Attitudes	Overall attitude score	MLR	β = 0.22 (95 % CI 0.09–0.35)	< 0.001	Positive

Note. Only significant predictors (p < 0.05) presented. Non-significant comparisons omitted for brevity. Abbreviations: MLR = Multiple Linear Regression; CI = Confidence Interval.

DISCUSSION

Overview of Findings

This study provides the first quantitative insight into the challenges and attitudes of private-sector optometrists in Malaysia toward implementing PEC. Using the validated CAPEC instrument, the findings confirm that while optometrists encounter moderate barriers, particularly in institutional support and professional recognition, they remain highly motivated and express a strong sense of professional responsibility toward PEC adoption. These results extend the earlier qualitative phase of this research, providing empirical support to previously reported themes such as limited workplace resources, lack of policy acknowledgement, and influence of patient expectations (Yahaya et al., 2023).

Challenges to Implementing PEC

Among the four challenge domains, *Support and Recognition* emerged as the highest-rated barrier. This indicates that optometrists perceive a lack of systemic backing from professional bodies, government agencies, and other healthcare stakeholders. Similar issues were raised in prior local and regional studies that described insufficient acknowledgment of optometric roles in preventive eye care, as well as ambiguity in referral

pathways between optometrists and ophthalmologists (Chew et al., 2018; George et al., 2019). The persistence of these barriers suggests that improving the professional recognition framework—including clearer PEC policy integration and cross-sector collaboration—is vital for sustainable service expansion.

The *Working Environment* and *Self-Sufficiency* domains reflect intra-practice factors. Limited clinical instruments and high patient load were among the issues identified in the qualitative phase, consistent with this survey's moderate mean scores. The positive relationship between *Self-Sufficiency* and attitudes suggests that continuing professional development (CPD) programmes focusing on ocular disease detection, public health screening, and PEC management could strengthen practitioners' confidence and readiness to adopt broader PEC services.

The *Customer Influence* domain remains a critical determinant of PEC success. Many optometrists reported that public awareness and acceptance shape their service offerings. This finding aligns with studies showing that patients' perception of optometrists as "glasses providers" restricts demand for clinical eye care services (Yahaya et al., 2023; Mohidin & Hashim, 2011). Educational campaigns and patient engagement strategies could therefore complement institutional reforms to boost PEC utilisation.

Attitudes Toward PEC Practice

Despite the barriers, optometrists demonstrated commendably high *Motivation* and *Sense of Responsibility* scores. This reflects a strong intrinsic drive rooted in professional ethics and patient-centred care values. Comparable trends were reported among optometrists in Australia and the UK, where positive attitudes predicted PEC-related behaviour despite external limitations (Holden et al., 2015; Efron et al., 2020). In this study, ownership and independence in practice also showed some influence on self-efficacy and perceptions of support, suggesting that autonomy may reinforce professional accountability.

Regression analyses confirmed that *Support and Recognition*, *Self-Sufficiency*, and *Customer Influence* are significant predictors of positive attitudes. This finding underscores the interconnectedness between external environment and internal motivation, consistent with social–cognitive and planned-behaviour frameworks (Ajzen, 1991). Hence, interventions aiming to enhance PEC implementation should target both structural and psychosocial determinants—support systems, CPD, and public perception—to translate positive attitudes into tangible behavioural change.

Implications for Policy and Practice

The high motivation among private optometrists represents an opportunity for policymakers to leverage this readiness. Integration of PEC services into national primary healthcare frameworks, supported by clear referral protocols and recognition from the Ministry of Health and MOC, could foster collaboration between public and private sectors. Incorporating CAPEC-based assessments in periodic national surveys could further monitor workforce readiness and identify emerging training needs.

Academic institutions and professional associations should also play an active role in embedding PEC competencies within undergraduate and postgraduate curricula, ensuring graduates possess both clinical and public health literacy. Continuous engagement with the public through health education may shift patient perceptions and strengthen demand for PEC.

Strengths and Limitations

A key strength of this study is its use of a validated, psychometrically robust tool (CAPEC), enabling reliable quantification of attitudes and challenges in a previously underexplored population. The national coverage of participants enhances representativeness. Nonetheless, the study's cross-sectional design limits causal inference, and self-reported responses may be subject to social desirability bias. Additionally, as recruitment was conducted through online self-selection, the sample may have been skewed toward younger and more digitally active optometrists, potentially underrepresenting the perspectives of older practitioners**.** Future longitudinal or interventional studies could assess how targeted training or policy interventions modify attitudes and behaviours over time.

Conclusion of Discussion

Collectively, this study reinforces that private optometrists in Malaysia possess strong professional readiness to contribute to PEC expansion but require greater systemic support, recognition, and patient cooperation. Bridging these gaps through coordinated policy, education, and awareness initiatives could significantly enhance the country's capacity to deliver equitable and sustainable eye care services.

CONCLUSION

This study provides quantitative evidence of the readiness of private optometrists in Malaysia to implement Primary Eye Care (PEC) services. Despite encountering moderate challenges—particularly in institutional support, recognition, and workplace limitations—optometrists exhibit strong motivation and a high sense of professional responsibility towards PEC delivery. Factors such as professional support, self-confidence, and patient cooperation play a crucial role in shaping positive attitudes and implementation behaviour. Strengthening institutional frameworks, fostering public–private collaboration, and enhancing continuing education initiatives could collectively accelerate the integration of PEC into private practice, improving national eye care accessibility and outcomes.

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CONFLICT OF INTEREST

The authors declare no conflict of interest related to this study.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used *ChatGPT (OpenAI, GPT-5)* to assist in manuscript organization, language refinement, and formatting based on the author's original content, analyses, and results. After using this tool, the author reviewed and edited the content as needed, taking full responsibility for the final version of the manuscript.

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REVIEW ARTICLE

The Effects of Stretching, Strengthening and Combined Interventions on Lower-Limb Spasticity in Spastic Cerebral Palsy: A Systematic Review

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ABSTRACT

Background: Spastic cerebral palsy (CP) is a common childhood neurological condition that results in abnormal muscle tone, motor dysfunction, and gait impairments. While stretching is widely used to reduce muscle stiffness, strengthening exercises are increasingly incorporated to improve functional mobility. Concerns remain, however, regarding whether strengthening may increase spasticity. **Method**: This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A comprehensive search of studies published between 2004 and 2024 was conducted across major databases. Eligible studies included those evaluating stretching, strengthening, or combined interventions targeting lower-limb spasticity in individuals with spastic CP. Risk of bias was assessed using the Cochrane Risk-of-Bias tool (ROB-2). **Results:** Twelve studies met the inclusion criteria. Intervention categories comprised stretching alone (n = 2), strengthening alone (n = 2), and combined stretching–strengthening programmes (n = 8). Findings indicated that stretching alone and strengthening alone do not consistently reduce lower-limb spasticity, although both may help preserve muscle and joint properties. Combined exercise programmes demonstrated mixed outcomes: some studies reported improvements in tendon stiffness, fascicle length, and clinical spasticity scores, while others showed no significant effects. Despite inconsistent spasticity outcomes, several studies noted functional gains, including better gait performance, enhanced muscle morphology, and improved movement efficiency. **Conclusion:** Overall, the evidence suggests that while combined interventions may offer selective benefits, reductions in spasticity are not uniformly observed. Current evidence does not support stretching, strengthening, or combined exercise programmes as consistently effective in reducing lower-limb spasticity in spastic CP, although functional improvements are frequently reported. Future research should prioritise spasticity as a primary outcome, standardise intervention parameters, and incorporate larger, methodologically robust samples to inform clinical practice.

INTRODUCTION

Cerebral palsy (CP) is one of the most frequently encountered physical disabilities in children. It is defined as a permanent and non-progressive disorder of movement and posture caused by abnormalities in the developing brain (Sadowska et al., 2020). CP leads to limitations in mobility and daily living activities, including walking, dressing, and self-care (Hallman-Cooper & Cabrero, 2024). In Malaysia, CP affects an estimated 2–5 children per 1,000 births, of whom about 65% present with spastic subtype (Sundaresan et al., 2022; Azzimawati, 2017). Spastic CP is characterised by abnormal muscle tone, hyperreflexia, and stiffness of major lower-limb muscles, including the gastrocnemius-soleus complex, hamstrings, adductors and psoas (Bar-On et al., 2015), which can contribute to gait abnormalities and difficulty performing daily tasks. Spasticity may lead to secondary musculoskeletal complications such as pain, contractures, and joint subluxations, further reducing independence and quality of life. Management strategies include physiotherapy, pharmacological interventions (e.g., botulinum toxin), and surgical options such as selective dorsal rhizotomy (Pavone et al., 2016; Rana et al., 2017). While pharmacological and surgical methods have established benefits, their invasive nature and costs make physiotherapy-based interventions an essential component of long-term management (Das & Ganesh, 2019).

Stretching is commonly used to preserve or increase range of motion and reduce muscle tightness (Wiart et al., 2008), whereas strengthening addresses muscle weakness, improves stability, and supports functional mobility (Shin et al., 2016). However, questions remain regarding whether strengthening exercises may

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worsen spasticity. Understanding the combined effects of stretching and strengthening is therefore essential for developing effective rehabilitation programmes.

The prevalence of spastic CP has shown a declining trend in high-income countries, but the trends remain uncertain in low- and middle-income countries (Villamor, 2022; McIntyre et al., 2022). Given the persistent burden of spasticity and its impact on activities of daily living (Hallman-Cooper & Cabrero, 2024), this systematic review aimed to critically evaluate and synthesise the evidence regarding the efficacy of stretching, strengthening, and their combination in reducing lower-limb spasticity in individuals with spastic CP.

METHODS

This systematic review was conducted following PRISMA guidelines (Page et al., 2021). The PICOS framework was used to guide the search and selection process. Studies were eligible if they examined stretching, strengthening, or combined interventions in paediatric or adolescent spastic CP and included outcome measures related to lower-limb muscle tone such as the Modified Ashworth Scale (MAS), Modified Tardieu Scale (MTS), Muscle-Tension Unit (MTU), tendon stiffness, or popliteal angle.

For databases like Google Scholar, ProQuest and Scopus which do not use MeSH terms, free-text keywords were utilised. The search terms used in these databases included the following combinations: “spastic cerebral palsy” AND “stretching” OR “range of motion” AND “spasticity" for the effectiveness of stretching exercises, “spastic cerebral palsy” AND “strengthening exercise*” OR “resistance exercise*” OR “resistance training” AND “spasticity” for strengthening exercises and "spastic cerebral palsy" AND "stretching" AND "strengthening exercise*" OR "resistance training" OR "resistance exercise*" for the effect of combined exercises.

Screening was completed in two phases: title/abstract screening and full-text review. A single reviewer performed initial screening, with supervisory consultation when uncertainties occurred. Studies published between 2004 and 2024 and written in English or Bahasa Malaysia were considered. The date range (2004–2024) was selected because strengthening interventions for paediatric CP began entering contemporary clinical research in the early 2000s, accompanied by increased use of biomechanical and tendon-morphology measures relevant to spasticity outcomes. Exclusion criteria included animal studies, Botulinum toxin Type A (BTX-A) administration within six months, surgical interventions, or inadequate methodological rigour.

The ROB-2 tool assessed randomisation, intervention adherence, missing data, outcome measurement, and selective reporting (Sterne et al., 2019).

RESULTS

Study Selection

Database searches yielded a large initial pool of articles (Google Scholar: 10,020; PubMed: 7,962; ScienceDirect: 164,113; ProQuest: 596,610; MEDLINE: 662; Malaysian Theses Online: 0). Following duplicate removal (n = 310,749) and relevance screening, 356 articles underwent abstract review. Twelve studies ultimately met all inclusion criteria. Figure 1 in Appendix 1 demonstrates the PRISMA flow diagram for each stage of the study.

Assessment of Bias

Using ROB-2, nine articles demonstrated low risk of bias, and three studies showed some concerns. Two quasi-experimental studies (Wu et al., 2011; Zhao et al., 2011) were rated as high risk due to study design limitations while Ryan et al. (2020) showed some concern for not reporting the number of exact dropouts. Despite these issues, all studies were retained due to the limited number of trials addressing spasticity outcomes.

Study Characteristics

The 12 included studies comprised participants aged 4–19 years from Europe, Asia, and North America, with most classified within GMFCS Levels I–III. Outcome measures varied and included the MAS, MTS, MTU properties, tendon stiffness, popliteal angle, and other biomechanical indicators such as fascicle length and pennation angle. The studies differed in eligibility criteria, with several requiring participants to ambulate independently, and one study (Engsberg et al., 2006) specifying minimum passive dorsiflexion thresholds and the ability to perform active dorsiflexion and plantarflexion. Four studies evaluated stretching-only or strengthening-only interventions, while eight examined combined stretching and strengthening

programmes. Across all trials, no severe adverse events were reported. Table 1 in Appendix 2 summarises the characteristics of included studies.

Stretching Interventions

Two studies (Kruse et al., 2022; Kruse et al., 2023) assessed static versus proprioceptive neuromuscular facilitation (PNF) stretching. A single session of static stretching produced acute improvements in MTU length, although no significant changes were noted for muscle belly or Achilles tendon elongation. Over eight weeks, neither PNF nor static stretching resulted in significant changes in MTU resting length, strain, or muscle belly properties.

Strengthening Interventions

Two studies (Kruse et al., 2019; Yazici et al., 2023) examined strengthening alone. Kruse et al. (2019) observed improvements in MTU length and gastrocnemius morphology following progressive resistance training. Yazici et al. (2023) demonstrated improvements in dorsiflexor and plantar flexor spasticity using MTS scores, particularly in R1 and R2 values.

Combined Interventions

Eight studies evaluated combined stretching and strengthening. Findings were mixed:

- Significant improvements in tendon stiffness, fascicle length, or clinical spasticity were reported by Kalkman et al. (2019), Cho & Lee (2020), Ryan et al. (2020), and Wu et al. (2011) and Engsberg et al. (2006), who noted strength-related changes despite limited spasticity reduction.
- Non-significant findings were observed in Fosdahl et al. (2019), Lee et al. (2008), and Zhao et al. (2011).

Variability in outcomes likely reflects differences in study duration, exercise intensity, spasticity measurement methods and the use of closed kinetic chain (CKC) versus open kinetic chain (OKC) exercises.

DISCUSSION

Effectiveness of Stretching

Although stretching remains one of the most common physiotherapy strategies for managing spasticity, evidence from recent studies suggests that its effects on neural components of tone are limited. As demonstrated in the work of Kruse et al. (2022, 2023), neither static nor proprioceptive neuromuscular facilitation stretching produced meaningful changes in MTU properties over an eight-week period. These findings reinforce earlier observations by Theis et al. (2015), who reported that improvements in muscle extensibility following stretching tend to be short-lived and predominantly mechanical rather than neurophysiological. This implies that stretching may temporarily lengthen soft tissues through viscoelastic deformation but does not substantially influence reflex hyperexcitability, which is the core driver of spasticity.

Collectively, the evidence indicates that stretching alone is better suited for maintaining joint range of motion and reducing the risk of contractures rather than modifying tone itself. This is consistent with clinical observations where stretching is often used as a preparatory technique prior to functional training rather than as a standalone intervention for reducing spasticity. However, the lack of measurable changes in muscle belly or tendon elongation in CP populations, despite regular stretching, suggests that long-standing spasticity and muscle morphology changes may limit the responsiveness of tissues to passive stretching. Therefore, stretching may still play a supportive role in rehabilitation but is unlikely to produce clinically meaningful reductions in spasticity when used independently.

Effectiveness of Strengthening

Strengthening interventions have traditionally raised concerns among clinicians due to the belief that increasing muscle force might exacerbate spasticity. However, evidence from Kruse et al. (2019) and Yazici et al. (2023) challenges this assumption. Both studies reported improvements in MTU length, gastrocnemius morphology, and MTS parameters without any indication of increased tone. These findings align with the neuromuscular rationale proposed by dos Santos et al. (2011), who emphasised that strengthening, particularly using CKC tasks can enhance motor unit recruitment, improve joint stability, and promote more efficient muscle activation patterns.

The observed improvements in MTU length and R1/R2 values suggest that strengthening may indirectly influence mechanical factors contributing to spasticity, such as stiffness and reduced tendon compliance.

Importantly, these changes occurred without provoking adverse reflex responses, indicating that strengthening, when appropriately dosed and supervised, is safe for individuals with spastic CP. CKC exercises may be particularly beneficial because they promote co-activation around joints, enhance proprioceptive input, and encourage functional movement patterns, all of which support better motor control.

The overall evidence therefore supports the inclusion of strengthening in rehabilitation programmes, not only for improving function but also for potentially modulating aspects of muscle behaviour associated with spasticity.

Effectiveness of Combined Interventions

The combined stretching-and-strengthening approach produced the most varied findings in this review, with some studies reporting favourable effects and others showing little or no change. Studies such as those by Kalkman et al. (2019), Cho and Lee (2020), Ryan et al. (2020), Wu et al. (2011), and Engsberg et al. (2006) reported improvements in tendon stiffness, fascicle length, strength parameters, or clinical spasticity scores, suggesting that integrating strengthening immediately after stretching may capitalise on increased muscle elongation and improved readiness for activation. In particular, Engsberg et al. (2006) demonstrated strength-related improvements despite limited reductions in spasticity, supporting the premise that combined programmes may enhance neuromuscular performance even when tone change is minimal. This sequential approach could theoretically reduce short-term passive resistance while reinforcing voluntary motor pathways through strengthening.

However, other studies such as those by Fosdahl et al. (2019), Lee et al. (2008), and Zhao et al. (2011) did not demonstrate significant changes in spasticity, despite similar combined protocols. Several factors may explain this heterogeneity. First, intervention intensity varied considerably across studies, ranging from low-resistance exercises to more structured progressive loading. Second, the duration of intervention was inconsistent, with some programmes lasting only four weeks—potentially too short to induce structural or neural adaptations. Third, outcome measures differed substantially; while some studies relied on clinical scales such as the MAS, others assessed biomechanical variables such as tendon stiffness or fascicle length, making comparisons challenging.

Another important variable is the type of strengthening exercise. CKC-based programmes (e.g., those implemented by Cho and Lee, 2020; Ryan et al., 2020) appear more effective in influencing muscle–tendon behaviour and functional outcomes than mixed OKC/CKC programmes. CKC tasks tend to be more functional and involve greater sensory feedback, potentially contributing to improved reciprocal inhibition and reduced co-contraction mechanisms that may influence spasticity expression. The inconsistency across studies appears substantially driven by heterogeneity in outcome measures. Whereas some studies assessed spasticity using clinical scales such as MAS or MTS, others evaluated biomechanical properties such as tendon stiffness, fascicle length, or muscle–tendon unit behaviour. These outcomes capture different constructs and are not directly comparable, which limits synthesis and contributes to the lack of consensus observed in this review.

Overall, the evidence suggests that combined programmes may improve selected structural or functional outcomes but do not consistently reduce spasticity across all individuals. The variability highlights the need for clearer intervention parameters, including exercise intensity, duration, muscle groups targeted, and progression criteria. A further limitation relates to study selection. Screening and eligibility assessment were performed by a single reviewer with supervisory consultation during uncertainties. While common in student-led reviews, this approach may introduce selection bias and is less rigorous than dual independent screening recommended for systematic reviews.

CONCLUSION AND FUTURE DIRECTIONS

Overall, the available evidence does not show consistent reductions in lower-limb spasticity with stretching, strengthening, or even when the two are combined. Stretching appears helpful mainly for preserving joint mobility, strengthening may contribute to changes in muscle structure and control, and combined programmes can offer certain functional benefits. However, these improvements do not always translate into clear or sustained changes in spasticity itself. This inconsistency across studies suggests that stronger and more focused research is still needed before firm clinical guidance can be established.

Future work should place spasticity at the centre of

outcome measurement and adopt more uniform approaches to exercise intensity, duration, and progression. Larger, well-controlled studies would also help ensure that findings are more applicable to the wider CP population. In addition, clearer reporting of orthotic use is important to avoid confounding interpretations. Incorporating detailed biomechanical and neurophysiological assessments may further improve our understanding of how different exercise components influence spastic muscle responses over time.

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT (OpenAI) to assist with language refinement, organisation of content, and formatting according to journal guidelines. The authors subsequently reviewed, edited, and approved all content, and accept full responsibility for the final manuscript.

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Appendix 1

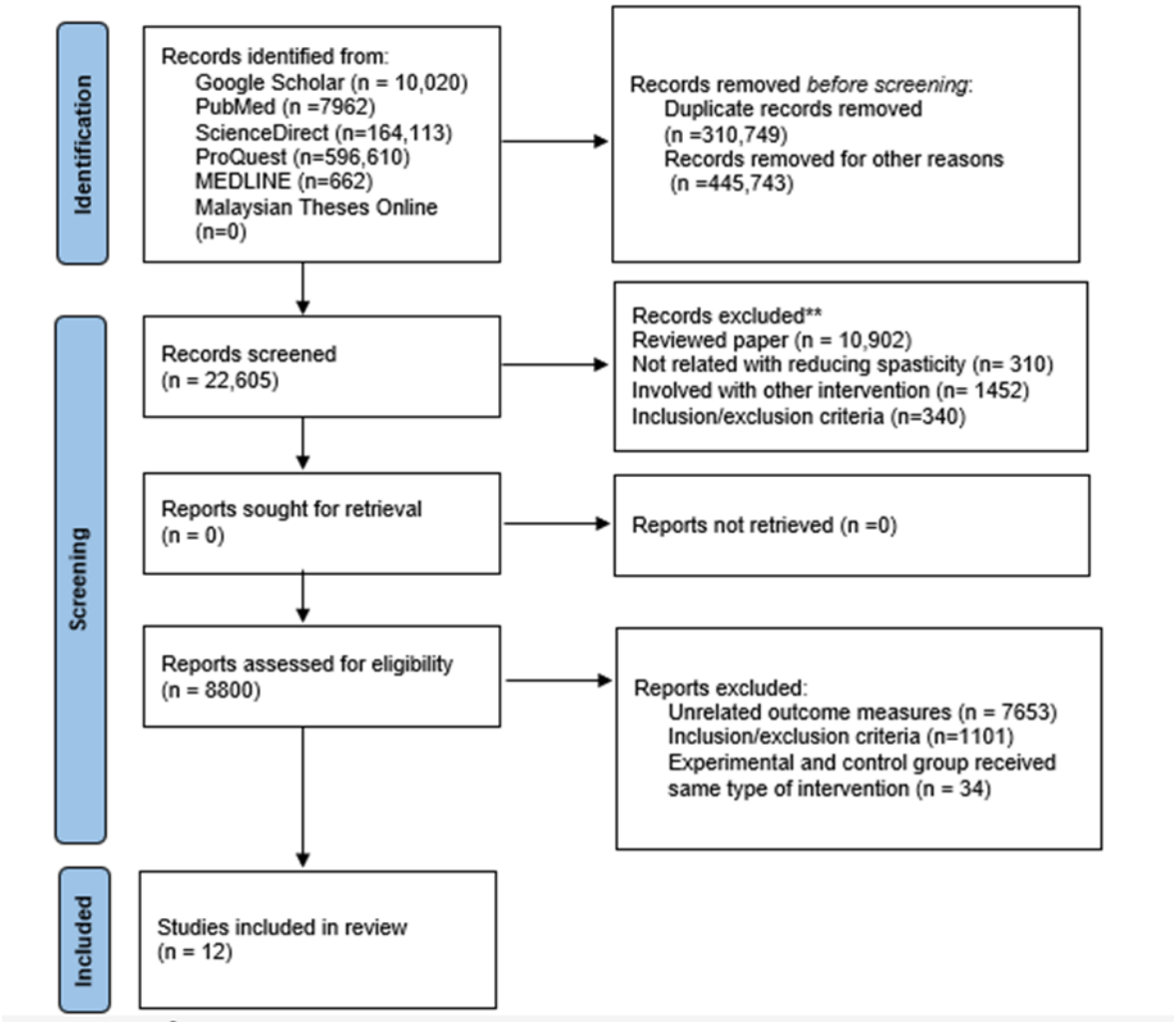

Figure 1 The PRISMA flow diagram for each stage of the study.

Appendix 2

Table 1 Characteristics of Included Studies

Author/ Country/ Title	Study design/ RoB	Participants/ Inclusion criteria/ Duration of study	Intervention	Outcome measure	Dropouts/Result
Kruse et al. (2022) Austria Acute Effects of Static and Proprioceptive Neuromuscular Facilitation Stretching of the Plantar Flexors on Ankle Range of Motion and Muscle-Tendon Behavior in Children with Spastic Cerebral Palsy—A Randomized Clinical Trial	RCT/Low	Participants (n=18), randomly divided into two groups Inclusion criteria: Age between 6-15years old Diagnosed with unilateral or bilateral spastic CP GMFCS level I-III Able to ambulate Able to follow instruction Had no severe contracture (defined as maxDF more or equal to 0° with knees extended) Exclusion criteria Received BTX injection 6 months prior Received any form of lower limb surgery 12 months prior Duration of study: 1 session	IG (n=8) Received: SS exercise: - In prone position with knees extended, therapist applied passive ankle DF to the available range (30s hold, 30s rest) -repeat in knees flexed position CG (n=10) Received: PNF: In prone position with knee extended, therapist applied passive ankle DF until tolerable range. Participants perform submaximal isometric contraction for 3-5s. Ankle then moved to greater DF and held for 25s. Rest for 30s. All exercises were repeated 10 repetitions on both legs.	Ankle ROM and maxDF Gastrocnemius MTU Muscle belly elongation AT elongation	Post-intervention No dropouts reported <u>MTU</u> <u>IG</u> Pre:18.3mm Post:20.9mm ***p=0.05** <u>CG</u> Pre:20.3mm Post:18.5mm p=0.670 <u>Muscle belly elongation</u> <u>IG</u> Pre:12.9mm Post:12.9mm p=0.465 <u>CG</u> Pre:13.6 Post:12.5 p=0.484 <u>AT elongation</u> <u>IG</u> Pre:5.4mm Post:8.0mm p=0.06 <u>CG</u> Pre:6.7mm Post:6.0mm p=0.272
Kruse et al. (2023) Austria Eight weeks of proprioceptive neuromuscular facilitation	RCT/Low	Participants (n=24), randomly divided into two groups Inclusion criteria: Age between 6-15years old Diagnosed with unilateral or bilateral spastic CP	IG (n=11) Received: SS exercise: - In prone position with knees extended, therapist applied passive ankle DF to the	Ankle ROM and maxDF Foot sole angle change Resting angle Peak externally applied torque Muscle activation Gastrocnemius MTU	Post-intervention After dropouts (n=20) IG (n=10) CG (n=10) <u>MTU</u> <u>(data in mean (SD)</u>

stretching and static stretching do not affect muscle-tendon properties, muscle strength, and joint function in children with spastic cerebral palsy		GMFCS level I-III Able to ambulate Able to follow instruction Had no severe contracture (defined as maxDF more or equal to 0° with knees extended) Exclusion criteria Received BTX injection 6 months prior Received any form of lower limb surgery 12 months prior Duration of study: 8 weeks	available range (30s hold, 30s rest) -repeat in knees flexed position CG (n=13) Received: PNF: In prone position with knee extended, therapist applied passive ankle DF until tolerable range. Participants perform submaximal isometric contraction for 3-5s. Ankle then moved to greater DF and held for 25s. Rest for 30s. Exercises were repeated four times a week at home All exercises were repeated 10 repetitions both legs.	Muscle belly elongation Gastrocnemius muscle fascicle lengths and lengthening AT elongation	<u>Resting length</u> <u>IG</u> Pre:0.94 (0.04) Post:0.95 (0.02) p=0.511 <u>CG</u> Pre:0.97 (0.02) Post:0.96(0.04) p=0.635 <u>MTU lengthening</u> <u>IG</u> Pre:0.05 (0.00) Post:0.05 (0.01) p=0.652 <u>CG</u> Pre:0.05 (0.01) Post:0.05(0.01) p=0.338 <u>Resting muscle belly length</u> <u>IG</u> Pre:0.49 (0.06) Post: 0.50 (0.07) p=0.880 <u>CG</u> Pre:5.5 (0.7) Post:5.1 (0.8) p=0.726 <u>MTU strain</u> IG: p=0.880 CG:p=0.726 <u>Muscle belly strain</u> IG: p=0.963 CG: p=0.708
Kruse et al. (2019) Austria The Effect of Functional Home-	RCT/Low	Participants (n=27) divided into two groups, Progressive Resistance Training (PRT) (IG) and High Intensity Circuit Training (HICT) (CG)	IG (n=12) Receive: Stretching exercises: Full body stretching for warm up (10 minutes)	Muscle and tendon morphological properties Ankle joint ROM Torque	Post-intervention After dropouts (n=22) IG (n=11) CG (n=11) Data in mean (SD)

Based Strength Training Programs on the Mechano-Morphological Properties of the Plantar Flexor Muscle-Tendon Unit in Children with Spastic Cerebral Palsy	Inclusion criteria: Age between 8 to 16 years old GMFCS level I and II Not having any contracture of PF (mx ankle DF >4° with knees extended) Able to walk independently Able to follow verbal instruction Exclusion criteria Forms other than spastic CP BTX injection in the past 6 months Previous surgery of ankle PF in the past 6 months Participants with epilepsy Duration of study: 24 weeks, 8 weeks of intervention, 16 weeks follow-up	and cooling down (5 minutes) Strengthening exercises: 1.sit to stand 2.heel raises 3.forward lunges 4.lateral step-up exercise 5.bridging exercise (10-12 repetitions for three sets with 2 minutes rest between sets) Resistance progressively increased with a weighted vest using 10 RM test Exercises were performed for 3 sessions per week for 8 weeks CG (n=15) Receive: Same treatment as IG group but with different load. Load was determined by the number of repetitions that could be completed within 30-second interval. No additional load was given. (Participants were told to perform as many repetitions as they could for 30 seconds, followed by 30 seconds rest in between)	Tendon mechanical and material properties	<u>Muscle Tendon property</u> <u>1.MTU length</u> <u>IG</u>: Pre: 1.08 (0.03) Post: 1.10 (0.03) Follow-up:1.08 (0.02) p-value<0.05 for pre-post and post-follow-up <u>CG</u>: Pre:1.08 (0.03) Post: 1.08 (0.02) Follow-up:1.09 (0.01) <u>2.AT length (normalised)</u> IG: Pre:0.57 (0.05) Post: 0.57 (0.05) Follow-up:0.54 (0.005) CG: Pre:0.55 (0.07) Post:0.54 (0.06) Follow-up: 0.54(0.06) <u>3. GM belly length</u> IG Pre: 0.52 (0.06) Post: 0.53 (0.05) Follow-up: 0.53 (0.06) CG: Pre: 0.53 (0.06) Post: 0.54 (0.05) Follow-up:0.54 (0.06) p-value<0.05 for post-follow-up <u>4.AT cross-sectional area (mm^2)</u> <u>IG:</u> Pre:43.7 (7.9) Post:44.2 (9.9) Follow-up:45.8 (10.6) <u>CG:</u> Pre:51.5 (22.8) Post:50.0 (18.3) Follow-up: 48.8 (19.1)

Yazici et al. (2023) Turkey Effects of progressive functional ankle exercises in spastic cerebral palsy, plantarflexors versus dorsiflexors: a randomized trial	RCT/Low	Participants (n=27), randomly divided into three groups, DF, PF and DF&PF exercises Inclusion criteria: Age between 5 to 15 years old Diagnosed with spastic unilateral or bilateral CP GMFCS level I and II Able to follow simple instruction Exclusion criteria Had BTX in the past 6 months Undergone orthopaedic operation in the past year Conditions which limit the ability to exercise Duration of study: 6 weeks	All group received functional exercise program targeting muscle of 1.abdominal 2.back 3.hip extensor 4.abductors 5.quadriceps Group A (n=9) DF exercise Received: 1.Walking up on a ramp 2.Walking down on ramp backwards 3.DF while sitting (knee in flexion) (intensity was increased by adjusting the degree of knee flexion) Group B (n=9) PF exercise Received: 1.Calf raises -difficulty was increased by increasing the degree of PF. At the beginning, movement was initiated from PF in shortened position. At the end of week 2, the exercise was conducted in foot flat on the surface followed by foot in DF. Group C (n=9) DF&PF Received: Both exercises given for GA and GB Exercises done 4 sessions per week (2 sessions for 45	MTS PBS FRT TUG MVC	Post-intervention After dropout (n=22) Group A (n=8) Group B (n=8) Group C (n=6) Result reported in IQR MTS Affected side Group A Slow (R2) (°) Pre: 10 (3.5/12.5) Post:15 (10/20) *p=0.015 Rapid (R1) (°) Pre: 0 (-1.5/7.5) Post:12 (7.5/17.5) *p=0.008 Difference Pre: 5 (0/10) Post: 0 (0/6.5) P=0.092 Group B Slow (R2) (°) Pre:10 (7/15) Post: 10 (10/20) p=0.197 Rapid (R1) (°) Pre: 5 (1/9.5) Post: 10 (5/15) *p=0.042 Difference Pre:6 (3/9.5) Post: 5 (0/7.5) p=0.260 Group C Slow (R2) (°) Pre: 10 (2.5/20) Post: 15 (9/20) p=0.104 Rapid (R1) (°) Pre: 0 (-7.5/7.5)

		minutes at with a PT and 2 sessions as home under supervision of caregiver)	Post: 10 (9/15) *p=0.017 Difference Pre:10 (5/15.5) Post: 5 (0/7.5) *p=0.049 Less affected side Group A Slow (R2) (°) Pre: 20 (11.5/20) Post:20 (15/20) p=0.465 Rapid (R1) (°) Pre: 10 (10/20) Post:20(15/20) *p=0.039 Difference Pre: 0 (0/7.5) Post: 0 (0/0) P=0.066 Group B Slow (R2) (°) Pre:15 (10/20) Post: 20 (13.5/20) p=0.0.465 Rapid (R1) (°) Pre: 10 (5/11) Post: 15 (11/20) p=0.092 Difference Pre: 5 (0/10) Post: 0 (0/0) p=0.206 Group C Slow (R2) (°) Pre: 20 (17.5/20) Post: 20 (10/20) p=0.102 Rapid (R1) (°) Pre: 20 (15/20) Post: 20 (10/20) p=1.000 Difference

					Pre:0 (0/2.5) Post: 0 (0/0) p=0.180 p value between group=0.140
Kalkman et al. (2019) **United Kingdom** Resistance Training Combined with Stretching Increases Tendon Stiffness and Is More Effective than Stretching Alone in Children with Cerebral Palsy: A Randomized Controlled Trial	RCT/Low	Participants (n=22), randomly divided into two groups Inclusion criteria: Age between 7 to 14 years old Diagnosed with spastic CP GMFCS level I-III Ability to perform at least one bilateral heel raise Exclusion criteria Received BTX injection 6 months prior to testing Have baclofen pump Any lower-limb neuro-or orthopaedic surgery Duration of study: 10 weeks	IG (n=12) Stretching exercise 1.ankle active stretching -1 minutes, 30 repetitions with 30 seconds rest in between Strength training: 1.unilateral heel raises -3 sets 12 repetitions Only strength training was performed in the first 4 weeks followed by combined intervention in another 6 weeks. Exercises were performed 4 times a week which 1 session was supervised and other 3 were performed at home. CG (n=10) Strength training for upper extremities Stretching exercise: ankle active stretching (1 minutes, 30 repetitions with 30 seconds rest in between)	Tendon stiffness during maximal voluntary isometric plantarflexion contraction (MVC) Resting fascicle length	Post-intervention Participants (n=16) IG (n=9) CG (n=7) <u>Tendon stiffness</u> Group A: 13.6N/m Group B: 1.5N/m p-value= 0.04 <u>Resting fascicle length</u> Group A: 2.2mm Group B: -0.5mm *p-value=0.02
Fosdahl et al. (2019) **Norway**	RCT/Low	Participants (n=37), randomly divided into two groups Inclusion criteria: Age between 7 to 15 years old	IG (n=17) Stretching exercise: 1.active knee extension	Passive and active popliteal angle (PPA and APA) Hamstring catches using Modified Tardieu Scale	Post-intervention (Intervention group compared to control group)

Stretching and Progressive Resistance Exercise in Children with Cerebral Palsy: A Randomized Controlled Trial	Diagnosed with spastic bilateral CP GMFCS level I-III PPA 35° or more on the most affected leg Exclusion criteria BTX injections in the LL for the last 6 months Surgical procedure on hamstring or bilateral lengthening of the triceps surae Other surgical procedure in the lower limbs less than 1 year prior to inclusion Less than 0° DF in the ankle joint Less than 5° external rotations in the hips Not able to cooperate or understand instructions Duration of study: 32 weeks, 16 weeks of interventions (T1) followed by 16 weeks of maintenance (T2)	(5 seconds) followed by passive stretching (40 seconds) 2.seated hamstring stretch (45 seconds) -performed bilaterally 5 times Strength training: 1. multijointed PRE with loaded backpack -step up -squat -heel rise (progressive resistance) (repetitions progressed from 2 series of 12 repetitions to 3 series of 8 repetitions after 8 weeks) 2. terminal knee extension with manual resistance at distal leg Exercises were performed 3 times a week which 2 session was supervised and other 1 were performed at home. CG (n=20) Not introduced to new interventions	(MTS) R1 with 90° flexion of knee Isokinetic quadriceps and hamstring strength (Cybex 6000)	After dropouts Participants (n=34) IG (n=16) CG (n=18) The result was presented in mean difference (SD) <u>PPA and APA</u> <u>IG</u> <u>PPA</u> <u>Left</u> T0-T1:5.0 (4.8)) T0-T2:3.5 (4.3) p=0.315 <u>Right</u> T0-T1: 5.4 (4.8) T0-T2:1.5 (85.7) p=0.234 <u>APA</u> <u>Left</u> T0-T1: 6.7 (7.3) T0-T2: 3.8 (8.6) P=0.120 <u>Right</u> T0-T1:9.2 (8.5) T0-T2: 5.0 (8.5) p=0.144 <u>CG</u> <u>PPA</u> <u>Left</u> T0-T1:1.0 (5.3) T0-T2:0.3 (5.5) p= 0.432 <u>Right</u> T0-T1: 1.2 (6.0) T0-T2:1.3 (5.4) p=0. 820 <u>APA</u> <u>Left</u> T0-T1: -1.6 (10.3) T0-T2: -1.7 (10.1) P=0.424 <u>Right</u> T0-T1:1.8 (8.8)

					T0-T2: 1.0 (10.2) p=0.705 <u>Hamstring catch</u> <u>IG</u> <u>Left</u> T0-T1: 0.7 (10.1) T0-T2: 1.9 (7.9) p=0.747 <u>Right</u> T0-T1: -1.2 (13.5) T0-T2: -0.7 (9.2) p= 0.749 <u>CG</u> <u>Left</u> T0-T1: 0.7 (7.3) T0-T2: -1.8 (9.2) p=0.744 <u>Right</u> T0-T1: 0.8 (12.0) T0-T2: -4.7 (9.2) p=0.744
Cho & Lee (2020) Korea Effect of Functional Progressive Resistance Exercise on Lower Extremity Structure, Muscle Tone, Dynamic Balance and Functional Ability in Children with Spastic Cerebral Palsy	RCT/Low	Participants (n=25), randomly divided into two groups Inclusion criteria: Age between 6 to 13 years old Diagnosed with spastic diplegic CP GMFCS level I-III Able to follow instructor's instruction Exclusion criteria Received any treatment for spasticity (surgery or BTX injection) in the last 6 months Has any disease that interfered with physical activity Duration of study: 6 weeks	IG (n=13) Stretching exercise: ROM stretching for 3 minutes prior to the session and 2 minutes at the end of the session Strength training: 1. sit to stand (5 minutes) 2. half-kneeling standing up (10 minutes) 3.side step-up (10 minutes) Exercises were performed 30 minutes per day, 3 times a week CG (n=12) Received: conventional therapy	Knee extensor strength Rehabilitative Ultrasound Imaging (RUSI) Muscle tone: Popliteal angle (PA) in active (-A), passive (-P) and speed (-S) (Electronic goniometer) Dynamic balance GMFM	Post-intervention No dropouts reported <u>IG (p-value)</u> PPA (non- dominant) = 0.030 PPA (dominant) =0.018 SPA (non-dominant) =0.014 SPA (dominant)=0.065 APA (non-dominant) =0.001 APA (dominant)=0.000 <u>CG</u> PPA (non- dominant) =0.101 PPA (dominant) =0.978 SPA (non-dominant) =0.163 SPA (dominant)=0.303 APA (non-dominant) =0.104 APA (dominant)=0.485 Between group PPA (non- dominant) = 0.046

			1.functional electrical stimulation (FES) 2.mat activity 3.standing frame		PPA (dominant) = 0.020 SPA (non-dominant) =0.025 SPA (dominant)=0.222 APA (non-dominant) =0.346 APA (dominant)=0.213
Ryan et al. (2020) **United Kingdom** Strength Training for Adolescents with cerebral palsy (STAR): study protocol of a randomised controlled trial to determine the feasibility, acceptability and efficacy of resistance training for adolescents with cerebral palsy	RCT/ Moderate	Participants (n=64), randomly divided into two groups Inclusion criteria: Age between 12 to 19 years old Diagnosed with spastic CP GMFCS level I-III Ability to activate ankle plantarflexors actively (> 15°) Exclusion criteria BTX injection or serial casting in the past 6 months Had any orthopaedics surgery for LL in the past 12 months Unable to cooperate or follow instruction Duration of study: 22 weeks, 10 supervised session and 12 weeks home session	IG (n=33) Stretching exercise: Plantarflexor stretches before and after exercise Strength training: 1. seated straight knee calf press against resistance band 2. standing straight knee calf raise 3.standing straight knee calf raise with hack squat 4.seated straight knee calf press with leg press machine (All strength training were done 6-15 repetitions 50%-85% of 1 RM for 22 weeks) Exercises were performed 30 minutes per day, 3 times a week CG (n=31) Received: usual care, provided no progressive strengthening exercises were introduced	Gait efficiency Physical activity (accelerometer-Actigraph wGT3X) Participation-Assessment of Life Habits (Life-H) questionnaire Muscle-tendon mechanics Muscle strength Muscle anatomical cross-sectional area Tendon-cross sectional area Muscle and tendon length Muscle and tendon stiffness (Young's modulus) Muscle, tendon and fascicle strain Treadmill walking	Post-intervention After dropouts Participants (n=52) Group A compared to Group B <u>Knee flexion angle during mid stance</u> Mean difference: -10.94° p<0.001 <u>Achilles tendon stiffness</u> Mean difference: +206.00MPa p=0.034
Wu et al. (2011) **USA** Combined Passive Stretching and Active Movement Rehabilitation of	Quasi-experimental /Moderate	Participants (n=12) Inclusion criteria: Age between 5 to 15 years old Diagnosed with spastic CP GMFCS level I-III	Receive: Stretching exercises: passive stretching of DF and PF 1.20 minutes for warm up	Passive ROM (PROM) of DF Active ROM (AROM) of DF Joint stiffness MTS MAS DF and PF muscle strength	Post-intervention No dropouts reported <u>MTS</u> p=0.02 at DF but no changes were seen at other joints

Lower-Limb Impairments in Children with Cerebral Palsy Using a Portable Robot		Able to walk with an assistive device independently Had enough cognitive ability to actively participate in the training protocol Exclusion criteria No surgical within the preceding year and serial casting withing 6 months Duration of study: 6 weeks	2.10 minutes for cooling down Strengthening exercises: 1.active assisted PF and DF to the available PROM (15 minutes) 2.resisted PF and DF within available AROM (15 minutes) Exercises were performed 3 sessions per week for 6 weeks	Selective Control Assessment of the Lower Extremity (SCALE) Functional outcome (PBS, 6MWT and TUG)	<u>MAS</u> p=0.01 at both PF and DF <u>PROM</u> <u>DF</u> Pre: 20.7±4.6° Post:26.6±4.9° (P=0.002) <u>AROM</u> <u>DF</u> Pre: 3±6.4° Post:10.1±8.7° (P=0.02) <u>Joint stiffness</u> Pre: 0.19±0.04 N m/° Post: 0.17±0.04 N m/° (P=0.03)
Zhao et al. (2011) USA Changes of calf muscle-tendon biomechanical properties induced by passive-stretching and active-movement training in children with cerebral palsy	Quasi-experimental/ Moderate	Participants (n=7) Inclusion criteria: Age between 5 to 15 years old Diagnosed with spastic CP GMFCS level I-II Able to walk with an assistive device independently Had enough cognitive ability to actively participate in the training protocol Duration of study: 6 weeks	Receive: Stretching exercises: passive stretching (20 minutes for warm up, 10 minutes for cooling down) Strengthening exercises: resisted plantarflexion and dorsiflexion active movement by the robotic device within their ROM Exercises were performed 3 sessions per week for 6 weeks	Fascicle length and pennation angle Fascicular stiffness Tendon properties *all measuring the soleus and gastrocnemius muscles	Post-intervention No dropouts reported <u>Fascicle length</u> *Soleus at full knee extension and 0° ankle dorsiflexion* Pre: 24.8±8.2 mm Post:26.8±8.6 mm P=0.018 *Soleus at 90° knee flexion and 0° ankle dorsiflexion* Pre: 40.2±6.6 mm Post:41.5±5.9 mm P=0.018 *GM at full knee extension and 0° ankle dorsiflexion* Pre: 24.8±8.2 mm Post:26.8±8.6 mm P=0.018 *GM at 90° knee flexion and 0° ankle dorsiflexion* Pre: 29.3±6.2 mm Post:30.9±5.5 mm P=0.018

Pennation angle

Soleus at full knee extension and 0° ankle dorsiflexion
Pre: 24.5±4.8°
Post:22.1±4.5 °
P=0.028

Soleus at 90° knee flexion and 0° ankle dorsiflexion
Pre: 24.9±4.9 °
Post:22.3±4.6°
P=0.028

GM at full knee extension and 0° ankle dorsiflexion
Pre: 16.7±2.9°
Post:16.0±2.8°
P=0.028

GM at 90° knee flexion and 0° ankle dorsiflexion
Pre: 21.9±4.0 °
Post:20.8±3.3°
P=0.043

Fascicular stiffness

Soleus at full knee extension and 0° ankle dorsiflexion
Pre: 33.3±10.4 N/mm
Post:27.6±12.5N/mm
P=0.128

GM at full knee extension and 0° ankle dorsiflexion
Pre: 12.2±3.8 N/mm
Post:9.6±3.6 N/mm
P=0.018

Achilles Tendon Mechanical Properties

Achilles tendon length
Pre: 55.7 ± 9.9 mm
Post: 52.6 ± 9.4 mm
P=0.018

					Achilles tendon stiffness Pre: 86.8 ± 16.9 N/mm Post: 114.4 ± 16.0 N/mm P=0.018 *Young's modulus* Pre: 113.6 ± 34.9 MPa Post: 136.8 ± 38.8 MPa P=0.018
Lee et al. (2008) **Korea** Therapeutic effects of strengthening exercise on gait function of cerebral palsy	RCT/Low	Participants (n=16), randomly divided into two groups Inclusion criteria: Age between 4 to 12 years old Diagnosed with spastic diplegic or hemiplegic CP GMFCS level II-III Able to walk with or without walking aids Exclusion criteria Had BTX or phenol injections in the LL Surgical procedure on the LL Medical or orthopaedic diseases that prevent from exercising Had fixed contracture at the knee or hip joint of more than 25° Not able to cooperate or understand instructions Duration of study: 5 weeks	IG (n=9) Stretching exercise: 1.whole body stretching Strength training: 1. squat to stand 2. lateral step up 3. stair walk up and down 4. isotonic exercise of LL 5. isokinetic exercise using bicycle Exercises were performed 3 times a week, 60 minutes for a session. CG (n=8) Received: 1.conventional therapy (NDT, ROM exercise and gait training)	GMFM Muscle tone (MAS) Muscle strength (MMT) Functional test (lateral step up and squat to stand)	Post-intervention No dropout reported <u>MAS</u> No significant changes in all patients of the experimental and control groups
Engsberg et al. (2006) **USA** Increasing Ankle Strength to Improve Gait and Function in Children with Cerebral Palsy: A Pilot Study	RCT/Low	Participants (n=15) divided into two groups, IG and CG. IG was further divided into three groups, PF, DF and PF&DF Inclusion criteria: Age below 18 years old Diagnosed with spastic diplegic CP	IG (n=12) Stretching exercise: 1.Gentle passive movement of the ankle throughout the ROM using the isokinetic device (10 minutes, prior and after strength training)	Ankle strength Ankle PF spasticity Gait GMFM Peds QL End range DF	Post-intervention After dropouts (n=12) IG (n=9) CG (n=3) Post-intervention <u>Spasticity (J/[°/S])</u>

	GMFCS level I-III Ability to ambulate with or without walking aids Have passive DF at least -5° with knee extended and no greater than 15° Hamstring length (90/90 test) to 45° or less Ability to perform active DF and PF for approximately 20° of total active range Able to perform six to eight repetitions of walking approximately nine metres Able to follow verbal instructions Exclusion criteria BTX injection in the LL in the past 6 months Orthopaedics intervention in the LL in the past 6 months Selective Dorsal Rhizotomy and intrathecal baclofen in the past 6 months Orthopaedics or medical problems that interfered with physical activity Motor deficits secondary to neurological injury/illness beginning after first month of life Children with moderate to severe dystonia, athetosis, ataxia Duration of study: 12 weeks	Strengthening exercises: 1. Eccentric and concentric contraction of DF, PF and DF&PF according to the designated group at different speed (30°/s and 90°/s). Each speed requires 3-5 repetitions for 6 sets, with 2 minutes rest between sets Exercises were performed 3 times per week for 12 weeks CG (n=3) Do not receive any treatment related to stretching or strengthening	IG (Combined DF,PF, DF&PF) Pre:0.012±0.007 Post:0.006±0.005 *p<0.001 Individual training PF Pre:0.012±0.009 Post:0.007±0.004 DF Pre:0.013±0.006 Post:0.004±0.003 PF&DF Pre:0.015 Post:0.008 CG Pre:0.011±0.004 Post:0.008±0.007 DF RoM (°) IG (Combined DF, PF, DF&PF) Pre:7±6 Post:12±5 p-value=0.073 Individual training PF Pre:8±4 Post:14±2 DF Pre:2±5 Post:10±6 DF&PF Pre:11 Post:10 CG: Pre:8±5 Post:10±4

**Only the results related to spasticity are presented. PBS= Paediatric Balance Scale; 6MWT= 6-minute walk test; TUG= Timed Up-and-Go test; Peds QL=Paediatrics Quality of Life questionnaire; FRT=Functional Reach Test; R1=The first point of resistance felt by therapist due to the catch result from the overactive stretch reflex; R2=passive joint ROM*

ORIGINAL ARTICLE

Chronotype and Its Association With Body Mass Index and Binge Eating Behaviour among Undergraduate Students

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ABSTRACT

Background: Chronotype, or an individual's preference for morning or evening activities, has a significant impact on their sleep-wake patterns. According to recent studies, chronotype may influence eating habits and body mass index (BMI), among other aspects of health. The purpose of this study is to look into the relationship between chronotypes and body mass index (BMI) and binge eating behaviour in undergraduate students. **Methods:** The cross-sectional study included 166 undergraduate students from USM Health Campus, with 86.1% females and a mean age of 21.1 ± 1.4 years. The Morningness-Eveningness Questionnaire (MEQ) and the 7-Item Binge-Eating Disorder Screener (BEDS-7) were used to assess chronotype and binge eating behaviour respectively. Meanwhile, BMI was calculated by measuring weight and height. **Results:** The chronotype distribution among university students indicated that 16.3% were categorised as morning types, 68.0% as intermediate types, and 15.7% as evening types. The mean chronotype score was 20.26 ± 8.37, signifying a moderate general preference with considerable individual variability. Binge eating behaviours are prevalent in 22.3% of university students, with a mean score of 3.04 ± 3.00. According to the updated CPG Obesity guidelines, the proportion of overweight and obese students increased from 21.7% to 31.3%. **Conclusion:** The chronotypes observed did not show any associations between binge eating behaviour (p=0.431) and BMI (p=0.422). More research is needed to shed light on the relationships between chronotype, BMI, and binge eating behaviour, as well as to identify other factors that may have a greater influence on BMI among university students. These results have the potential to influence the development of future student wellness programmes by emphasising the importance of broader lifestyle and psychological factors that extend beyond chronotype. The cross-sectional design of this study is a limitation, as it precludes the inference of causal relationships.

INTRODUCTION

Circadian rhythms vary among individuals and can be classified into three types based on their preferences: morning-type (M-type), evening-type (E-type), and intermediate-type (I-type), collectively known as chronotypes (Horne & Ostberg, 1976). Studies indicate that variations in chronotypes affect multiple physiological processes, including the immune system and the hypothalamus-pituitary-adrenal (HPA) axis (de Punder et al., 2019).

Furthermore, research has identified a correlation between chronotype and body mass index (BMI) (Sun et al., 2020), in addition to binge eating behaviour (Harb et al., 2012). Given that both BMI and dietary habits are essential indicators of metabolic health, understanding the influence of chronotype on these factors is crucial. Chronotype may affect health via behavioural and metabolic mechanisms; for example, evening chronotypes have been associated with unhealthy eating patterns such as nocturnal eating and binge eating, in addition to omitting breakfast, factors that may contribute to elevated BMI (Yang et al., 2023). Furthermore, individuals exhibiting binge eating behaviour are often found to possess a heightened BMI (Thu et al., 2019).

Prior research indicates a correlation between chronotypes and binge eating behaviour, with individuals of evening chronotypes exhibiting a higher propensity for binge eating compared to those of morning chronotypes (Harb et al., 2012). Binge eating behaviour is intricately linked to obesity and eating disorders. Binge Eating Disorder (BED) is an eating disorder marked by recurrent binge eating episodes, during which individuals experience a loss of control and considerable distress over their eating behaviours.

According to Halmi (2020), BED is the most prevalent eating disorder, with a lifetime prevalence of 3.5% in women and 2.0% in men in the United States. In contrast to other eating disorders, binge eating episodes in BED are

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not accompanied by purging, excessive exercise, or fasting, leading to a heightened risk of overweight or obesity in those affected. Given that evening chronotypes correlate with elevated BMI and a heightened propensity for binge eating episodes (Ekiz Erim & Sert, 2023), it is essential to investigate their impact on metabolic health.

BED can also occur in the late teens or early twenties (Kessler et al., 2013). In a population-based study, Udo and Grilo (2018) discovered that the median age of onset of BED was 21 years. Many young people in Malaysia fall into this age range because they are usually university students, a group that may be especially vulnerable to developing BED due to the stress associated with entering adulthood and the responsibilities that come with it (Pedrelli et al., 2015). This transitional phase is frequently characterised by erratic sleep patterns, poor dietary habits, and increased psychological stress, all of which may influence alterations in chronotype, BMI, and eating behaviours. Nonetheless, the literature reveals a limited comprehension of the prevalence of BED in this population.

The incidence of overweight and obesity among university students in Malaysia remains elevated. At Universiti Putra Malaysia, 19.6% of undergraduates were identified as overweight and 6.3% as obese (Suhaimi et al., 2020). In a public university, the prevalence of overweight and obesity among postgraduate students was 32.0%, comprising 23.1% overweight and 8.9% obese (Kabir et al., 2014). This is concerning due to the potential for unhealthy eating habits and irregular sleep patterns to persist into later life, which were established during early adulthood. A recent study involving Malaysian university students identified correlations between poor sleep quality, evening chronotypes, and postponed mealtimes with heightened appetite and alterations in body composition (Say et al., 2025). Chronotype and chrononutrition significantly influence dietary habits and metabolic results. Research indicates that university students possessing an evening chronotype exhibit a preference for high-calorie foods (Feng et al., 2022). Likewise, in Malaysian young adults, a morning chronotype and healthier sleep patterns correlated with reduced BMI, waist circumference, and visceral fat, whereas evening chronotypes exhibited significantly elevated adiposity (Cheong et al., 2024). Building on this evidence, a substantial study involving Malaysian women (n = 934) revealed that detrimental chrononutrition behaviours, such as skipping breakfast, eating late in the evening, and consuming the largest meal at night, were significantly associated with abnormal BMI and compromised sleep quality, underscoring the influence of meal timing on weight management and sleep health (Teh et al., 2023). Comprehending the correlation between chronotype, BMI, and binge eating behaviour within this demographic can facilitate the development of culturally relevant campus initiatives, including chronotype-oriented counselling, sleep hygiene programmes, and obesity prevention strategies for students who are at risk.

Recent research has focused on the link between chronotypes and health outcomes, particularly dietary intake and metabolic indicators. Nonetheless, little research has been conducted on the impact of chronotypes on BMI and binge eating behaviours in young adults. Recognising that dietary habits and lifestyle choices formed during university frequently last into adulthood is critical for developing preventive health strategies. As a result, the purpose of this study is to look into the relationship between chronotypes and BMI among undergraduate students, as well as their relationship with binge eating behaviour. It is hypothesised that individuals possessing an evening chronotype will exhibit a higher BMI and an increased propensity for binge eating behaviour in comparison to those with morning or intermediate chronotypes. This research question was developed to elucidate the impact of chronotype on health-related behaviours and metabolic outcomes within a Malaysian university student demographic, thereby guiding the formulation of early, targeted preventive interventions

MATERIALS AND METHODS

This study utilises a cross-sectional design. The data collection took place from October 2023 to December 2023. This study was conducted with undergraduate students from the School of Medical Sciences, School of Dental Sciences, and School of Health Sciences at Universiti Sains Malaysia, Kubang Kerian, Kelantan. The inclusion criteria specified participants aged 18 to 25 years who are undergraduate students enrolled in the School of Medical Sciences, School of Dental Sciences, or School of Health Sciences.

The exclusion criteria included the presence of medical conditions (e.g., hypertension, hyperlipidaemia, depression, asthma, arthritis) or a diagnosis of any psychiatric disorder. The choice of undergraduate students is supported by a population-based study by Udo & Grilo (2018), which determined that the median age of onset for binge eating disorder (BED) is 21 years. This age aligns with that of numerous young adults in Malaysia, as the majority are enrolled in university. During this transitional phase into adulthood, individuals may be especially susceptible to developing BED due to the heightened stress linked to new responsibilities (Pedrelli et al., 2015).

This study required 166 participants, calculated using Daniel's formula (Daniel, 1999) (n=sample size, Z= z statistic for a level of confidence at 95%, the Z-score value for the 95% confidence level is 1.96).

$$n = \frac{Z^2\ P\ (1-P)}{d^2} \quad (1)$$

According to a study conducted among university students in Malaysia, 10% of the participants exhibited binge eating behaviour (Thu et al., 2019). The anticipated proportion of the population is 0.10. For the study, a 20% attrition rate is included in the calculation. The USM Human Research Ethics Committee approved this study (Reference Code: USM/JEPeM/KK/23060455) as well as the Deans of the School of Medical Sciences, School of Dental Sciences, and School of Health Sciences.

Data Collection Method

The data collection began immediately following ethical approval. Individuals eligible for this study received the subject recruitment poster via social media platforms. This poster was distributed in conjunction with the recruitment message to recruit eligible participants for the ongoing study. The recruitment message for this study was distributed to class representatives from various courses at the Universiti Sains Malaysia (USM) Health Campus.

Participants who met the inclusion and exclusion criteria for this investigation were invited to participate. The data was collected using Google Forms, as undergraduate students were accustomed to completing online questionnaires. Nevertheless, the researcher conducts physical anthropometric measurements. During the data collection period, the researcher initially supplied the study participant with a Google Form link that contained the Participant Information Sheet, Material Publication Consent Form, and questionnaires accessible via a QR code or link. The researcher conducted the anthropometric measurements of participants immediately after obtaining their consent to participate.

Anthropometric weight measurements were taken using a high-capacity digital flat scale (SECA 813), which was calibrated to zero before use. The respondents stood barefoot and placed their hands on the scale in a relaxed position. The participants were positioned upright, with their heels aligned and their gaze directed forward, and their height was measured using a portable stadiometer (SECA 213). Two measurements of weight and height were obtained and documented, and the mean value was used to calculate BMI. The BMI was subsequently categorised in accordance with the WHO classification and the Clinical Practice Guidelines (CPG) for the Management of Obesity (CPG Obesity, 2023). The data collection process lasted two months, yielding a total of 166 responses. The data from the initial 166 respondents were subsequently analysed. The final sample contained a higher proportion of female participants as a result of the online recruitment strategy and the voluntary nature of sampling. This gender imbalance is recognised as a limitation of the study and is addressed accordingly. Convenience sampling was implemented as a result of the academic semester's time and logistical constraints. Although probability sampling has the potential to improve generalisability, the current methodology was selected to guarantee the timely collection of data.

Research Tools

The questionnaire, which has four sections and 36 questions, was created using Google Forms. Each section contains a variety of questions, with respondents required to answer all questions in Sections A, B, and D, while the researcher completed Section C. This section utilised the Morningness–Eveningness Questionnaire (MEQ) and the 7-item Binge Eating Disorder Screener-7 (BEDS-7). Both questionnaires are accessible online free of charge, and permission was obtained from the original authors before their utilisation in this study.

Section A: Socio-Demographic Data

This section gathers data pertaining to individuals' personal information and socio-demographic attributes, including age, gender, ethnicity, educational institution, year of study, and socioeconomic status. The collected data were excluded from the statistical analysis due to their status as confounding factors. Future studies should examine the impact of these socio-demographic variables on the correlation between chronotype, BMI, and binge eating behaviour.

Section B: Morningness–Eveningness Questionnaire (MEQ)

The Morningness–Eveningness Questionnaire (MEQ) is employed as a tool in Section B to investigate chronotype (Horne & Ostberg, 1976). An authorisation was obtained from the original author of the MEQ for its use in this study. A student demographic aged 18 to 32 years was initially employed and validated for MEQ. Cavallera and Boari (2015) have shown that the New Zealand version exhibits a high degree of internal consistency (Cronbach α coefficient=0.83). The questionnaire consists of 19 multiple-choice questions that are intended to collect data from respondents by evaluating their morningness and

eveningness preferences through self-reported responses.

In this section, participants were asked to specify their preferred times for waking up or falling asleep, rather than their actual times. Each multiple-choice response is assigned a numerical score between 0 and 6 points. The cumulative scores differ between 16 and 86. Horne and Ostberg (1976) classified participants as either evening type (scores between 16 and 41), neither type (scores between 42 and 58), or morning type (scores between 59 and 86).

Section C: Body Mass Index (BMI)

Section C seeks to collect information on respondents' weight and height in order to compute their Body Mass Index (BMI). This section has been finalised by the researcher. The researcher measured respondents' weight and height twice in the Highly Integrated Learning and Living Space (The HILLS) at the USM Health Campus, utilising a high-capacity digital flat scale (SECA 813) and a portable stadiometer (SECA 213), respectively. The BMI is determined by dividing weight in kilogrammes by the square of height in meters and is categorised according to the World Health Organisation (WHO) classification and Clinical Practice Guidelines (CPG) for the Management of Obesity (CPG Obesity, 2023).

Section D: 7- item Binge Eating Disorder Screener-7 (BEDS-7)

The Binge Eating Disorder Screener-7 (BEDS-7) is employed in Section D to evaluate binge eating behaviour (Herman et al., 2016). The original authors of the BEDS-7 granted permission for its use in this investigation. BEDS-7 is a screening tool that was created by Takeda with the objective of identifying adults who are suspected of having binge eating disorder (BED). Alhaj et al. (2022) have reported that the results of the study yield a Cohen's Kappa value of 0.827, with a sensitivity of 100% and a specificity of 38.7%.

This questionnaire comprises seven questions. Abdulla et al. (2023) included a 4-point combined severity/frequency scale in each question to project the degree to which the participants had encountered each item of the BEDS-7 within the past 3 months. The scale options included 0 (never or rarely), 1 (sometimes), 2 (often), and 3 (always). The cumulative score for each individual is derived by summing the scores from the BEDS-7. Individuals with a total score below 5 are considered to have normal eating habits, while those with a score of 5 or higher exhibit symptoms of binge eating (Abdulla et al., 2023).

Statistical Analysis

The Statistical Package for Social Sciences (SPSS) version 28.0 was used to enter and analyse the data. Descriptive statistics are used to summarise the socio-demographic characteristics of participants, including their age, gender, ethnicity, school of study, and year of study. Numerical data are represented as the mean (SD) or median (IQR) according to their normal distribution. Conversely, categorical data is represented as frequency (percentage).

Normality assessments, including the Shapiro-Wilk test, were used to ascertain the normal distribution of the data. The relationship between chronotype, body mass index, and binge eating behaviour among USM undergraduate students was tested using Pearson's Chi-Square test if expected count < 5 is less than 20% of the cells, or Fisher's Exact test if expected count < 5 more than > 20% of the cells. The significance level (α) was set to 0.05.

RESULTS

Characteristics of participants

The sociodemographic characteristics of the sample are summarised in Table 1. The mean age and mean BMI of the study were determined. The study had 166 participants, with a mean age of 21.1±1.4 years. Malays comprised the majority of the population (62%), followed by Chinese (25.9%), Indians (5.4%), and Others (6.6%) following in that order.

Females constituted 86.1% of the population. Regarding education, the majority of participants (84.9%) were affiliated with the School of Health Sciences, and 33.7% were fourth-year students. According to the Household Income & Basic Amenities Survey Report 2019 (2020), 92 participants (55.4%) were classified as B40, which means they had a monthly household income of RM4850 or less. Table 1 details the participants' characteristics.

Chronotype, BMI and BED

Table 2 provided an overview of the chronotype distribution among university students. There were 16.3% morning types, 68.0% intermediate types, and 15.7% evening types. The sample had a BMI of 22.1 (SD = 4.57) kg/m², and about 62% of the people in the study had a BMI between 18.5 and 24.9 kg/m², which is considered normal. According to the World Health Organisation (2000), 16.3% of the participants were considered underweight, while 21.7% were considered overweight or obese.

According to the new Clinical Practice Guidelines (CPG) for

obesity management, the prevalence of overweight and obese individuals rose to 31.3%, while the prevalence of individuals with normal weight declined to 52.4% (CPG Obesity, 2023). Table 2 shows that 22.3% of all participants engaged in positive binge eating behaviour (score ≥ 5 on the BEDS-7). The mean BEDS-7 score for the entire sample was 3.04 SD 3.00.

Association between Chronotype with BMI and BED

According to Table 3, there is no significant link between chronotype and Binge Eating Disorder (BED) ($p>0.05$). Furthermore, there was no significant correlation between chronotype and body mass index (BMI) ($p> 0.05$).

Table 1: Characteristics of participants (n=166)

Characteristics	n	%
Age (years), mean ± S.D.	21.1 ± 1.4	
Gender		
Female	143	86.1
Male	23	13.9
Ethnicity		
Malay	103	62.0
Chinese	43	25.9
Indian	9	5.4
Others	11	6.6
School of study		
Health Sciences	141	84.9
Medical Sciences	15	9.0
Dental Sciences	10	6.0
Year of study		
Year 1	37	22.3
Year 2	41	24.7
Year 3	32	19.3
Year 4	56	33.7
Year 5	0	0.0
Socioeconomic status		
B40	92	55.4
M40	64	38.6
T20	10	6.0

* B40: monthly household income ≤RM4850; M40: monthly household income between RM4850- RM10970; T20: monthly household income ≥RM10971

Table 2: Distribution of chronotype, BMI and binge eating behaviour among university students (n = 166)

	n	%
Morningness-eveningness questionnaire (MEQ), mean ± S.D.	20.26 ± 8.37	
Morning type	27	16.3
Intermediate type	113	68.0
Evening type	26	15.7
Body Mass Index (kg/m^2), mean ± S.D.	22.10 ± 4.57	
WHO Classification		
Underweight	27	16.3
Normal	103	62.0
Overweight	25	15.1
Obese	11	6.6
CPG for the Management of Obesity Classification		
Underweight	27	16.3
Normal	87	52.4
Overweight	32	19.3
Obese	20	12.0
Binge Eating Disorder Screener-7 (BEDS-7), mean ± S.D.	3.04 ± 3.00	
Absent	129	77.7
Present	37	22.3

Table 3: Association between chronotype with BMI and binge eating behaviour (n=166)

Variable	Chronotype (n = 166), n (%)			*p* value
	Morning type	Intermediate type	Evening type	
Binge Eating Disorder Screener-7				
Absent	19 (14.7)	91 (70.5)	19 (14.7)	0.431[a]
Present	8 (21.6)	22 (59.5)	7 (18.9)	
Body Mass Index				
Underweight	5 (18.5)	17 (63.0)	5 (18.5)	0.422 [b]
Normal	19 (18.4)	71 (68.9)	13 (12.6)	
Overweight and obese	3 (8.3)	25 (69.4)	8 (22.2)	

[a] *Tested using Pearson's Chi Square*

[b] *Tested using Fisher's exact test*

DISCUSSION

In this study, 68.0% of the participants classified as intermediate type, 16.3% as morning type, and 15.7% as evening type. Similarly, Rique et al. (2014) found that among medical students at a university in Brazil, 51.6% were classified as intermediate type, 27.6% as morning type, and 20.8% as evening type. Sun et al. (2020) conducted research among participants in the Bogalusa Heart Study, revealing that 42.2% were identified as morning type, 11.1% as evening type, and the remainder as intermediate type.

Most people have intermediate chronotypes, which means that their sleep-wake cycles are in sync with daylight. A smaller number of people, on the other hand, are extreme early or late risers. Chronotypes, also called diurnal preferences, are biological processes that are controlled by the circadian rhythm (Kalmbach et al., 2017). These preferences are influenced by intrinsic circadian variations (Papatsimpa et al., 2021). Extended circadian periods correspond to later chronotypes, whereas shorter periods correspond to earlier chronotypes.

Lack et al. (2009) discovered that intrinsic periods vary from 24.1 hours for morning types to 24.3 hours for evening types. Czeisler et al. (1999) and Duffy et al. (2001) documented an average human circadian cycle of 24.2 hours. This interval (24.1–24.3 hours) may elucidate the prevalence of intermediate chronotypes. Circadian systems inherently vary among populations, affecting diverse sleep preferences (Fischer et al., 2017). The median BMI, as per WHO criteria, was 22.1 ± 4.57 kg/m², falling within the normal range (World Health Organisation, 2000). The proportions we obtained align with certain prior research, though not universally. Our results aligned with the findings of Omar & Kudin (2023). While similar findings were reported by Kutty et al. (2015) and Wan Zakaria et al. (2021), our study found a higher prevalence of overweight and obesity (21.7%) than the study involving University Tunku Abdul Rahman (UTAR) students (13.2%), but a lower prevalence compared to students from UiTM Kelantan (34.8%) (Kutty et al., 2015; Wan Zakaria et al., 2021).

Although results indicate variability in BMI distributions among university students, the prevalence rose to 31.3% when assessed according to the new Clinical Practice Guidelines (CPG) for the Management of Obesity, underscoring the critical need for the development of strategies at the university level to effectively prevent and manage obesity (CPG Obesity, 2023). Consequently, effective intervention programmes, including sleep education and physical activity-based interventions, should be implemented to address overweight and obesity among university students (Lubas & Szklo-Coxe, 2019; Pfisterer et al., 2022).

According to the current study, 22.3% of university students binge eating behaviour. The prevalence was higher than that of previous research conducted on college and university students. In a study of 3,415 college students, 2.4% were found to have binge eating disorder (BED), compared to 10% in a sample of Malaysian university students (Solly et al., 2023; Thu et al., 2019). The heightened prevalence identified in this study may be attributed to the diverse instruments used to assess binge eating behaviour. This study utilises the 7-Item Binge-Eating Disorder Screener (BEDS-7) to assess Binge-Eating Disorder (BED).

In contrast, Solly et al. (2023) assessed BED using the self-reported Minnesota Impulse Control Disorders Interview (MIDI), while Thu et al. (2019) implemented the Binge Eating Scale (BES) questionnaire. Binge eating behaviour was identified in 21.2% of participants in a prior study by Abdulla et al. (2023), which employed the same assessment method as the current investigation. Consequently, the comparison of binge eating behaviour prevalence among study populations should rely on

studies employing identical assessment methodologies.

This is the first study in Malaysia to employ the BEDS-7 screening tool to identify individuals with binge eating behaviour, and to the best of our knowledge, it is the only available screening tool that is specifically designed for BED. BEDS-7 not only preserves the content of the DSM-5 criteria, but also provides a reasonable specificity of 38.7% and a maximal sensitivity of 100% (Herman et al., 2017). As a result, the BEDS-7 may be useful in helping medical professionals identify patients with BED.

Research on the relationship between chronotype and obesity yields conflicting results. Although some claim that eveningness is associated with a higher body mass index (BMI), the current study found no significant correlation between chronotype and BMI ($p>0.05$). This is consistent with a recent review which found no evidence linking chronotype to an increased risk of obesity (Kivelä et al., 2018). Walker et al. (2015) and Maukonen et al. (2016) found that chronotype does not appear to be a risk factor for obesity. Likewise, Harb et al. (2012) identified no correlation between the MEQ and BMI, contradicting earlier studies that indicated a relationship between morningness and a lower BMI. This result, despite its non-significance, motivates additional investigation into other moderating variables (e.g., stress, sleep duration, physical activity) that may impact the relationship between chronotype and BMIs.

The correlation between daily energy expenditure and body mass suggests that an increase in body mass is correlated with an increase in energy intake (Swinburn et al., 2009). Sato-Mito, Shibata, et al. (2011) conducted a study that revealed a lack of correlation between the chronotype score and daily energy intake, as well as no significant association between BMI and MEQ scores. Additionally, research has demonstrated that individuals with an evening chronotype exhibit unfavourable dietary habits and poorer health behaviours than those with a morning chronotype (Kanerva et al., 2012; Maukonen et al., 2016). Moreover, unhealthy dietary and lifestyle choices among Malaysian adults are recognised as factors contributing to their elevated global obesity rate. As a result, we hypothesised that poor dietary choices, which could or might not be influenced by an individual's chronotype, had an impact on BMI.

Prior studies have demonstrated a correlation between chronotype and eating disorders (Kandeğer et al., 2021; Romo-Nava et al., 2020). Individuals with an evening chronotype are often linked to bulimic and binge eating behaviours (Kivelä et al., 2018). Binge Eating Disorder (BED) is an eating disorder defined by recurrent episodes of binge eating, during which individuals experience a loss of control and significant distress regarding their eating behaviour (Iqbal & Rehman, 2022). Vera et al. discovered that evening chronotypes had significantly higher eating behaviour scores, as measured by the Three-Factor Eating Questionnaire (TFEQ), than morning chronotypes, implying decreased dietary control and an increase in stress-related eating incidents. Research suggests that individuals who engage in binge eating behaviours are more likely to identify with an evening chronotype (Harb et al., 2012; Romo-Nava et al., 2020). However, the present study revealed no correlation between chronotype and binge eating behaviours. This discrepancy may arise from the distinct assessment tool employed in the current study to identify binge eating behaviour, in contrast to previous studies that utilised various instruments such as the Eating Disorder Diagnostic Scale (EDDS), Three-Factor Eating Questionnaire (TFEQ), and Binge Eating Scale (BES) (Harb et al., 2012; Romo-Nava et al., 2020; Vera et al., 2018). This non-significant discovery underscores the significance of consistent research tools in the study of eating behaviour and chronotype, and it implies that assessment variability may influence the results.

Currently, evidence connecting an individual's chronotype to particular eating disorders remains scarce. A recent review indicated that dietary behaviours such as food addiction, hunger, eating duration, television viewing during meals, binge eating, and meal skipping were assessed only superficially; thus, further research is required to explore the relationship between chronotype and these eating habits (Mazri et al., 2019).

Several limitations should be taken into account in this study. First and foremost, the cross-sectional design restricts the capacity to infer causality between chronotype, BMI, and binge eating behaviour. Secondly, the employment of convenience sampling and the disproportionate representation of female participants may introduce selection bias, potentially impacting the generalisability of the results. Furthermore, self-reported data from instruments like the MEQ and BEDS-7 may be susceptible to response bias or underreporting. The study was confined to students from health-related faculties at a single university, potentially failing to represent the wider university student demographic in Malaysia. Subsequent research should prioritise random sampling, gender equity, and the inclusion of varied academic backgrounds to enhance representativeness and validity.

CONCLUSION

This research found no significant link between

chronotype and body mass index (BMI) or binge eating behaviour among public university students in Kelantan, Malaysia. The findings suggest that chronotype may not have a significant impact on BMI or binge eating; however, more research is needed to investigate other possible causes. The study found that regardless of the classification method used, the majority of students had a BMI within the normative range.

Nonetheless, the implementation of the new Clinical Practice Guidelines (CPG) for obesity management increased the proportion of overweight and obese students from 21.7% to 31.3%. Furthermore, 22.3% of students demonstrated signs of binge eating behaviour, emphasising the importance of initiatives aimed at assisting students in recognising and addressing these behaviours while maintaining a healthy BMI.

Even though chronotype did not play a significant role in this investigation, the substantial prevalence of binge eating and overweight status indicates the necessity of campus-based interventions that concentrate on mental health, nutrition education, and lifestyle modification.

Future research should concentrate on a more representative sample of students from all USM campuses to enhance the understanding of obesity and binge eating prevalence among Malaysian undergraduates. Simple random sampling would enhance the reliability and generalisability of the results. In addition, future research should take into account the inclusion of mediating variables, such as stress levels, sleep quality, and lifestyle behaviours, to gain a more comprehensive understanding of their indirect effects on the relationship among chronotype, BMI, and binge eating behaviour. Furthermore, future research may examine additional variables, such as lifestyle habits, dietary patterns, and psychological factors, that could demonstrate a more significant correlation with BMI and binge eating behaviour.

This research is one of the initial investigations in Malaysia examining the correlation between chronotype, BMI, and binge eating behaviour utilising the BEDS-7 screening instrument. The findings provide initial insights into a locally under-explored domain and may establish a basis for future longitudinal and behavioural studies focused on the early prevention of disordered eating among university students.

In conclusion, this investigation underscores the significance of early screening and preventive strategies in promoting student wellness, even when conventional predictors such as chronotype fail to demonstrate a robust correlation.

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CONFLICT OF INTEREST

The authors did not have a conflict of interest to declare.

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ORIGINAL ARTICLE

Dietary Patterns and Nutritional Status of School-Aged Children in Osogbo Local Government

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ABSTRACT

Background: Despite growing evidence of poor dietary intake and food insecurity among children in public primary schools, national nutrition efforts focus mainly on under-five children, leaving school-aged children underserved and increasingly vulnerable to malnutrition and its long-term health and learning consequences. This study assessed dietary patterns and nutritional status among school-aged children (5-10 years) in Osogbo Local Government, Osun State, Nigeria. **Methods:** A cross-sectional study was conducted among 393 public primary school pupils (175 boys and 218 girls). Dietary patterns were assessed using a structured food frequency questionnaire, while anthropometric measurements (weight and height) were obtained to determine nutritional status based on WHO growth standards. Associations between dietary patterns and nutritional status were examined. **Results:** Among the 393 pupils, 48.3% were underweight, 43.0% had normal weight, and 8.7% were overweight. Most children (90.6%) consumed home-packed meals and preferred rice, beans, and fish. The association between food consumption frequency and nutritional status was statistically significant and of moderate to strong magnitude (χ^2 = 66.2–110.8, p<0.001; Cramér's V =0.41–0.53). **Conclusion:** Undernutrition is highly prevalent among school-aged children in Osogbo, with 48.3% classified as underweight. Dietary patterns were significantly associated with nutritional status, highlighting the importance of improving diet quality and diversity among school-aged children.

INTRODUCTION

Malnutrition remains a persistent public health concern in many developing countries, driven by complex factors such as food insecurity, economic inequality, and limited access to nutrient-rich foods (Ilo et al., 2025). These challenges are particularly critical for school-aged children, who require adequate nutrition to support healthy growth, cognitive development, and academic performance (Asmare et al., 2018). Despite the importance of this age group, national nutrition programmes often focus primarily on children under five, leaving older children underserved and at increased risk of undernutrition. Growth monitoring in primary schools provides a useful tool for identifying nutritional problems early, yet data on dietary patterns and nutritional status among school-aged children in Osogbo remain limited.

Nutritional assessment, which includes measuring both undernutrition and overnutrition, is the standard way to evaluate children's health. In regions across Asia and Africa, undernutrition is especially widespread (Moseley & Battersby, 2020). Current UNICEF data indicate that among children and adolescents aged 5–19 years, the prevalence of underweight has declined to about 9.2%, while obesity has risen to approximately 9.4%, marking the first time obesity exceeds underweight worldwide (UNICEF, 2025). However, data on dietary patterns and nutritional status of school-aged children in Osogbo Local Government are limited, highlighting the need for this study.

In fact, almost half of all child deaths globally are linked to poor nutrition. National efforts have focused on undernutrition among under-five children, with recent reports indicating a 30% underweight prevalence in South-West Nigeria (Ogunniyi et al., 2023). However, less attention has been given to school-aged children, especially those in public schools, despite their increased vulnerability due to socio-economic challenges. Around 60% of child deaths from common illnesses like malaria or diarrhoea could have been prevented if those children had not lacked an adequate diet (undernutrition) to begin with (WHO,2016). Undernutrition is not the only form of malnutrition; overnutrition (excessive food intake) also contributes to malnutrition. Childhood obesity is rising globally — not just in wealthy nations, but also in low- and middle-income countries. It increases the risk of chronic diseases like heart conditions, diabetes, and hypertension later in life (Asmare et al. 2018; UNICEF, 2025).

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Childhood obesity and undernutrition are major public health challenges affecting school-aged children worldwide. Children who are overweight are more likely to remain obese into adulthood, with estimates suggesting that 40–60% of obese children carry the condition into their adult years (Umer, 2017). These trends have implications not only for individual health but also for healthcare systems and the global economy (Rito, 2021). Thus, early prevention of childhood obesity has become a critical goal for public health initiatives worldwide (Waters et al. 2018).

Nigeria's National Home-Grown School Feeding Programme (NHGSFP), reintroduced in 2016, aims to improve nutrition and school attendance by providing one nutritious meal per school day to pupils in public primary schools (World Bank, 2022). However, several studies have reported implementation challenges such as underfunding, irregular meal delivery, and inconsistent coverage across states (Onah & Onah, 2021; Agu et al., 2023). These gaps highlight the need to assess the dietary patterns and nutritional status of school-aged children in Osogbo Local Government, Osun State.

The study examined dietary patterns and nutritional status of school-aged children in public primary schools in Osogbo Local Government, Osun State, and explored the relationship between them.

MATERIALS AND METHODS

This study employed a cross-sectional, school-based design to examine the dietary patterns and nutritional status of school-aged children. Ten public primary schools were purposively selected from both urban and rural areas of Osogbo Local Government, Osun State, Nigeria, based on the approval and cooperation of local school authorities. The purposive selection of schools may limit generalizability beyond the study area.

Inclusion and Exclusion Criteria

The study included 393 school-aged children (5–10 years old) enrolled in public primary schools in Osogbo Local Government, Osun State, Nigeria. Participation was granted through parental consent. Children with chronic illnesses, physical disabilities, or acute illnesses at the time of measurement were excluded to ensure accurate assessment of nutritional status and dietary patterns.

Sample Size Determination

The sample size for this cross-sectional study was calculated using the formula for a single proportion as described by Leslie Kish (1965).

$$n = z2p(1-p)/d2 \quad (1)$$

Where,
n = Minimum desired sample size
z = the standard normal deviate usually set at 1.96, which corresponds to 5% significant level
p = prevalence of outcome of interest
d = degree of accuracy desired (precision), usually set at 5% (0.05)
p = 36.9% (Iheme, 2021)

$$n = \frac{(1.96)2 \times 0.369 \times (1 - 0.369)}{(0.05)2}$$

$$n = \frac{3.84 \times 0.369 \times 0.631}{0.0025}$$

$$n = \frac{0.894}{0.0025}$$

n = 357.6

10% of the value of n was added to replace the loss or incomplete questionnaires (10% of 357.6 = 35.76), therefore, 35.76+ 357.6 = 393.36, n = 393 (Approx.)

Data collection

Data collection was carried out using a structured questionnaire administered through oral interviews and anthropometric measurements conducted in a relaxed and conducive environment. The questionnaire was adapted from previously published school-based dietary surveys and pretested among pupils in a neighboring school. It comprised three sections: Section A addressed demographic and household information; Section B involved anthropometric measurements obtained following standard WHO procedures. A height meter (calibrated in centimeters) and a weighing scale (calibrated in kilograms and pounds) were used to obtain accurate physical measurements. Each measurement was taken twice, and the average value was recorded to minimize measurement error. Section C focused on dietary intake and food frequency. For pupils in lower primary classes (Primary One to Primary Four; approximately 5–8 years), the questionnaire was interviewer-administered, with responses recorded based on verbal reports. Where feasible, caregivers assisted in confirming habitual dietary intake for this age group. For pupils in Primary Five, who demonstrated sufficient literacy skills, responses were self-reported under the close supervision of the interviewer to ensure accuracy and engagement. This approach was adopted to encourage participation and minimize anxiety among the respondents. Data collectors were trained prior to the study on standardised measurement techniques and questionnaire

administration to ensure consistency and accuracy.

Data analysis

Data was analysed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize socio-demographic characteristics, dietary habits, and anthropometric indicators. Nutritional status (BMI-for-age) was computed using WHO AnthroPlus software based on the WHO 2007 growth reference standards.

Dietary habit scores were derived from six key behavioural indicators: number of meals consumed per day, preference for home-prepared meals, source of lunch, frequency of snack consumption, preference for protein sources, and consumption of sugary beverages. Each favourable dietary behaviour was assigned a score of 1, while unfavourable behaviours were assigned a score of 0, yielding a total possible score ranging from 0 to 6. Based on score distribution and commonly applied approaches in school-based dietary surveys, scores of 0–3 were categorised as poor dietary habits, while scores of 4–6 were categorised as good dietary habits. This classification was used solely to facilitate interpretation of overall dietary behaviour patterns.

Associations between dietary patterns and nutritional status categories (underweight, normal, and overweight) were examined using the chi-square (χ^2) test, and effect size was estimated using Cramér's V. Statistical significance was set at $p < 0.05$. Given that multiple chi-square tests were conducted across several food items, the risk of Type I error was addressed by adjusting p-values using the Benjamini–Hochberg false discovery rate procedure.

Ethical considerations

Ethical approval for the study was obtained from the Osun State University, College of Health Sciences Research Ethics Committee and parental consent was sought for learners to participate in the study and individual consent was obtained from learners. Consent was also sought from the head teachers of the conveniently sampled schools who served as the key gatekeepers. Participants did not receive any form of remuneration or incentives which could have influenced their participation.

Participation was voluntary and participants were free to withdraw from the study at any time without any negative consequences. All participant information was treated as confidential and anonymous as their only form of identification was a study code that was allocated to them. The contact details of the primary researcher and study supervisors were provided on both the written informed consent forms (for parents/legal guardians) and assent forms (for the pupils) in case additional information or clarification regarding the study was required.

RESULTS

Socio-Demographic Characteristics of the School-Aged Children in Osogbo Local Government

A total of 393 pupils participated in the study. Slightly more than half were girls, and the majority fell within the 7–10-year age group. Most respondents identified as Yoruba and practiced either Islam or Christianity. Household size was generally moderate, with most pupils living in families of four to six members. The occupational profile indicated that trading was the dominant source of livelihood for both fathers and mothers, while only a small proportion were civil servants or farmers (Table 1).

Table 1: Socio-demographic characteristics of the pupils (n=393)

Characteristics	Frequency	Percent
Gender		
Female	218	55.5
Male	175	44.5
Age group		
5-7	132	33.6
7-10	261	66.4
Ethnicity		
Yoruba	383	97.4
Igbo	7	1.7
Hausa	3	0.7
Religion		
Islam	218	55.4
Christianity	175	44.5
Family size		
Fathers		
Trading	300	76.3

Civil Servants	20	5.1
Farmer	10	2.5
Others	63	16.0
Mothers		
Trading	201	51.1
Civil Servants	33	8.4
Farmer	26	6.6
Others	133	33.8

Dietary Habits of the School-Aged Children in Osogbo Local Government

Most of the pupils reported eating three meals per day, with only a few consuming one or two meals daily. Nearly all children preferred homemade food, and the majority brought lunch from home rather than buying food in school. Snack consumption after school was also common among pupils. Meat was identified as the most preferred protein source, followed by egg and fish. Sugary beverages were widely consumed, with almost all respondents indicating intake. Overall, dietary habit scores showed that most pupils had poor dietary habits, with only about one-quarter demonstrating good dietary patterns (Table 2; Figure 1).

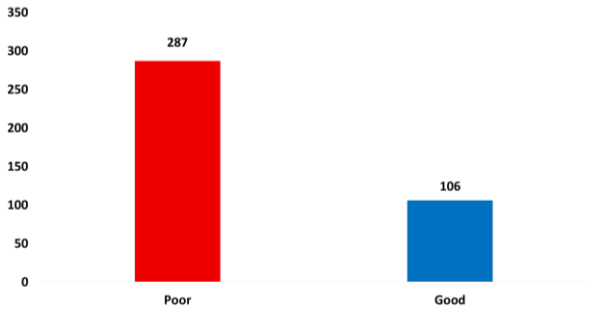

Figure 1: Dietary habit categories of respondents

Food Consumption Pattern of the School-Aged Children in Osogbo Local Government

Table 3 shows the food consumption patterns of the pupils. The majority regularly consumed staple foods such as rice (97.4%), beans (70%), and bread (74.5%). Spaghetti and Indomie were also commonly consumed, though to a slightly lesser extent. Fish were the most frequently consumed protein source (94.9%), while vegetables and fruits were consumed by about 70% and 52% of pupils, respectively. Cassava granules (garri) were consumed regularly by 60.3% of pupils. Overall, these results indicate a high consumption of staple and protein-rich foods, with lower intake of fruits, vegetables, and some carbohydrate alternatives.

Nutritional Status of the School-Aged Children in Osogbo Local Government

The anthropometric assessment of school-aged children (Table 4) revealed a high prevalence of undernutrition. Based on BMI-for-age percentiles (WHO growth standards), 48.3% of children were underweight (<5th percentile), 43.0% had normal weight (5th–85th percentile), and 8.7% were overweight (85th–95th percentile). The mean BMI-for-age was 15.8 ± 2.3 kg/m², indicating considerable variability within the population.

Table 2: Dietary Habits of the Pupils

Dietary Habits	Frequency	Percent
Home-made food preference		
Yes	393	100.0
No	0	0.0
Lunch source		
Buy at School	37	9.4
Bring Packed Lunch from Home	356	90.6
Snacks after school		
Yes	375	95.4
No	18	4.6
Meals per day		
Once	2	0.5
Twice	15	3.8
Thrice	376	95.7
Preferred source of protein		
Meat	250	63.6
Fish	70	17.8
Egg	73	18.5
Sugary beverages		
Yes	388	98.7
No	5	1.3

Table 3: Food Consumption pattern of the pupils (n (%))

Food	Always	Often	Sometimes	Rarely
Rice	383[97.45]	10[2.54]	0 (0.0)	0 (0.0)
Beans	275 [70]	75[19.1]	43[11]	0 (0.0)
Spaghetti	253L64.3]	90L23]	50[12.7]	0 (0.0)
Yam	200[50.8]	30[7.6]	150[38.1]	13[3.30]
Potatoes	200[50.8]	30[7.6]	150[38.1]	13[3.30]
Fish	373[94.9]	20[5.0]	0 (0.0)	0 (0.0)
Egg	312[79.4]	81[20.6]	0 (0.0)	0 (0.0)
Vegetables	278[70.7]	58[14.7]	58[14.7]	0 (0.0)
Garri	237[60.3]	70[17.8]	86[21.8]	0 (0.0)
Indomie	250[63.6]	63[16.03]	80[20.3]	0 (0.0)
Bread	293[74.5]	45[11.4]	55[13.9]	0 (0.0)
Fruits	205[52.1]	58[14.7	50[12.7	80[20.3
Cereals	136[34.6]	78[19.84]	59[15.0]	120[30.5]

Table 4: Anthropometry measurements of the pupils

Categories	Frequency	Percent
BMI		
Normal (5th – 85th percentile)	169	43.0
Overweight (85th – 95th percentile)	34	8.7
Underweight (Below 5th Percentile)	190	48.3
Mean ± SD = 15.8±2.3Kg/m²		

Table 5: Association between food consumption patterns and nutritional status of the pupils

Food	Consumption	Underweight n (%)	Normal n (%)	Overweight n (%)	χ^2	p
Rice	Frequent	190 (48.4)	169 (43.1)	34 (8.5)	38.52	<0.001
Beans	Frequent	157 (40.0)	161 (41.0)	32 (8.2)	17.32	<0.01
	Infrequent	33 (8.4)	8 (2.0)	2 (0.5)	—	—
Spaghetti	Frequent	170 (43.2)	149 (38.0)	24 (6.1)	62.78	<0.001
	Infrequent	20 (5.1)	20 (5.1)	10 (2.5)	—	—
Yam	Frequent	127 (32.3)	79 (20.1)	24 (6.1)	66.20	<0.001
	Infrequent	63 (16.0)	90 (22.9)	10 (2.5)	—	—
Potatoes	Frequent	127 (32.3)	79 (20.1)	24 (6.1)	66.20	<0.001
	Infrequent	63 (16.0)	90 (22.9)	10 (2.5)	—	—
Fish	Frequent	190 (48.4)	169 (43.1)	34 (8.5)	8.68	<0.05
Egg	Frequent	190 (48.9)	169 (43.0)	34 (8.1)	1.15	0.56
Vegetables	Frequent	190 (48.4)	169 (43.1)	34 (8.5)	8.68	<0.05
Garri	Frequent	170 (43.2)	142 (36.1)	24 (6.1)	42.94	<0.001
	Infrequent	40 (10.2)	27 (6.9)	10 (2.5)	—	—
Indomie	Frequent	165 (42.0)	110 (28.0)	32 (8.1)	87.45	<0.001
	Infrequent	50 (12.7)	74 (18.8)	2 (0.5)	—	—
Bread	Frequent	175 (44.5)	116 (29.5)	22 (5.6)	52.94	<0.001
	Infrequent	40 (10.2)	53 (13.5)	12 (3.1)	—	—
Fruits	Frequent	175 (44.5)	144 (36.5)	19 (4.8)	46.38	<0.001
	Infrequent	41 (10.4)	39 (9.9)	20 (5.1)	—	—
Cereals	Frequent	145 (36.9)	100 (25.4)	18 (4.6)	110.80	<0.001
	Infrequent	60 (15.3)	46 (11.8)	29 (7.4)	—	—

Values are presented as number (percentage). "Frequent" = Always + Often; "Infrequent" = Sometimes + Rarely.

Association between Dietary Patterns and Nutritional Status of the School-Aged Children in Osogbo Local Government

Table 5 shows the association between frequency of food consumption and nutritional status of the pupils. Significant associations of moderate to strong magnitude were observed between nutritional status and the consumption of rice ($\chi^2 = 38.52$, $p < 0.001$), beans ($\chi^2 = 17.32$, $p < 0.01$), spaghetti ($\chi^2 = 62.78$, $p < 0.001$), yam ($\chi^2 = 66.20$, $p < 0.001$), and potatoes ($\chi^2 = 66.20$, $p < 0.001$), with corresponding Cramér's V values ranging from 0.41 to 0.53. In each case, a higher proportion of pupils who frequently consumed these foods were classified as underweight or normal weight, with a smaller proportion being overweight.

Fish ($\chi^2 = 8.68$, $p < 0.05$) and vegetables ($\chi^2 = 8.68$, $p < 0.05$) also showed statistically significant associations with nutritional status, although the magnitude of association was comparatively lower. Egg consumption was not significantly associated with nutritional status ($\chi^2 = 1.15$, $p = 0.56$).

Further significant associations of moderate to strong effect size were observed for garri ($\chi^2 = 42.94$, $p < 0.001$), Indomie ($\chi^2 = 87.45$, $p < 0.001$), bread ($\chi^2 = 52.94$, $p < 0.001$), fruits ($\chi^2 = 46.38$, $p < 0.001$), and cereals ($\chi^2 = 110.80$, $p < 0.001$), with Cramér's V values within 0.41–0.53. Frequent consumption of these foods was more common among underweight pupils compared with overweight pupils.

After Benjamini–Hochberg false discovery rate correction, the association between consumption frequency of rice, beans, spaghetti, yam, potatoes, garri, Indomie, bread, and cereals remained statistically significant ($p<0.05$), while associations for fish and vegetables did not remain significant. Egg consumption showed no association with BMI.

DISCUSSION

This study examined dietary patterns and nutritional status among school-aged children in Osogbo Local Government and found a high prevalence of undernutrition, with 48.3% classified as underweight and 8.7% as overweight. These findings highlight nutritional challenges within this population and suggest the presence of multiple contributing factors.

Although most pupils reported eating three meals per day and nearly all snacks consumed regularly, this did not translate into optimal nutritional outcomes. These results align with a study which observed that frequent meal consumption in Ibadan did not necessarily ensure nutritional adequacy (Rasaki et al., 2022). In the present study, most pupils brought lunch from home, suggesting ongoing parental involvement. However, the reported meal composition suggests limited variety, which may reduce overall nutrient intake. School food environments, whether home-packed or purchased, influence dietary quality, emphasising the need for nutritious options across settings (Ogum-Alangea et al. 2020).

Food frequency data showed predominant consumption of carbohydrate-based staples, including rice, spaghetti, bread, Indomie, and garri. While many pupils reported consuming nutrient-rich foods such as fish, vegetables, and eggs, the relatively lower intake of fruits and cereals suggests limited dietary diversity. This pattern is consistent with earlier findings that children may rely heavily on affordable, filling staple foods while consuming nutrient-dense foods less consistently (Rasaki et al., 2022). The coexistence of frequent protein intake and high undernutrition may reflect factors not captured in the present study, such as portion size, energy density, food preparation methods, infection burden, or household food insecurity — all commonly associated with inadequate growth in children.

Associations between food consumption patterns and BMI were observed, with several food items showing statistically significant relationships of moderate to strong magnitude. Frequent consumption of energy-dense foods such as Indomie, spaghetti, and bread was significantly associated with BMI categories, whereas egg consumption showed no significant association. These findings suggest that variations in BMI may be related to combinations of foods rather than single items, and they may be influenced by broader dietary or environmental patterns. Similar studies have reported that limited dietary diversity, particularly when accompanied by processed food intake, is associated with suboptimal anthropometric outcomes, supporting the patterns observed here (Asakura et al., 2017; Asare et al., 2022). However, given the cross-sectional nature of the study, no causal inference can be drawn from these associations.

Almost all pupils reported regular consumption of snacks and sugar-containing foods or beverages. Although these were not evaluated quantitatively in the present study, high snacking frequency may displace nutrient-rich foods or increase overall energy imbalance, which could help explain the coexistence of underweight and overweight observed in the sample.

While socio-cultural and religious practices may play a role in shaping dietary choices, as reported by Jayasinghe et al. (2025), this study did not directly collect data on food taboos or restrictions. Therefore, such factors cannot be confirmed as explanatory contributors within the current sample. Instead, they remain potential considerations for future research.

Finally, the prevalence of undernutrition observed in this study is higher than that reported during the implementation of the National Home-Grown School Feeding Programme (Otunla et al., 2019). Although this comparison may indicate the potential role of structured nutrition-support programmes in improving child growth outcomes, the findings should be interpreted with caution Future longitudinal or comparative investigations are

warranted to clarify the impact of such interventions. Dietary intake data were obtained through pupil self-reports, an approach commonly employed in school-based surveys, which may not fully capture habitual intake patterns. Dietary diversity was assessed using consumption frequency, without quantification of portion sizes or nutrient composition. Inclusion of household-level dietary data, socio-economic indicators, and biochemical measures in future studies would enhance the robustness of evidence on the determinants of nutritional status.

CONCLUSION

This study demonstrates a substantial burden of undernutrition among school-aged children in Osogbo Local Government Area. Dietary patterns were associated with nutritional status, suggesting that overall diet quality may play a role alongside broader socio-economic and environmental factors. The findings underscore the importance of continued attention to the nutritional wellbeing of school-aged children through nutrition education, routine growth monitoring, and improved access to diverse, nutrient-rich foods. Further longitudinal studies are needed to clarify causal pathways and to examine the long-term implications of dietary patterns for health and learning outcomes.

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REVIEW ARTICLE

Advancements in Polymeric Biomaterials For In Vitro Expansion of Hematopoietic Stem Cells: A Scoping Review

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ABSTRACT

Background: A thorough source of HSPCs with a reduced risk of graft host disease (GVHD) is umbilical cord blood (UCB). Nevertheless, compared to peripheral blood or bone marrow stem cells, hematopoietic stem cells (HSCs) isolated from single cord blood are less common and require longer to settle in the bone marrow before they may begin generating blood cells. Earlier clinical trials were conducted to ensure bone marrow (BM) sustainability through the application of various natural and synthetic polymeric techniques. Usage of polymeric biomaterials can be seen as alternative to stabilise stem cell-based therapies currently. Therefore, this article aims to evaluate the data progress and compile the evidence of current advances of polymeric biomaterial for in vitro expansion of HSCs. **Methods:** Articles were found through four electronic search engines which were PubMed, Scopus, ScienceDirect and SpringerLink. The highlighted keywords utilised in this study to assist the research framework. The article selection followed Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines. Articles were included if they met the following criteria: (1) full text articles between 2019 until 2023; (2) specific keywords must have in the research articles; (3) published in English; (4) qualitative or quantitative study. Studies were excluded if they were review articles, chapter books, discussion papers or did not match with study objectives to achieve high quality of scoping review. **Results:** A total of 5,208 records were initially identified from the selected databases. After removing duplicates, a total of 5194 articles were screened, and 52 full-text articles were evaluated. There were 37 articles that did not match with the inclusion and exclusion criteria and had been excluded because the paper involved review paper and did not discuss the usage of biomaterials for expansion of HSCs. Lastly, only 15 articles were selected for scoping review analysis. **Conclusion:** The findings reveal that cultured polymeric biomaterials have had a significant impact on the stability and integrity of HSCs. Besides, the selected polymeric biomaterials can improve crosstalk or cell-cell interaction through laboratory settings. From this review, it can be concluded that the approach used by researchers truly aids the clinical institution to overcome the deficiency in stem cell therapies.

Keywords:
biomaterials; polymers; in vitro expansion; hematopoietic stem cells; bone marrow

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INTRODUCTION

Over the years, haematological disease has increased in human populations and become a burden towards clinical institution. According to World Health Organization (WHO), they stated that anaemia is one of common blood disorder worldwide and caused 50 million years of healthy life lost due to disability in 2019. Multipotential hematopoietic stem cells (HSCs) as a core of the immune system play a significant role in haematopoiesis. The bone marrow (BM) niche naturally supports human HSCs to undergo expansion, differentiation, and self-renewal for numerous cell types (Lucas, 2017). The uniqueness of BM that can produce diverse types of cell lineage has become a spotlight for researchers to establish stem cell-based therapies. The therapies can be performed via in vivo, ex vivo and in vitro method. This application aims to provide an efficient clinical test by augmenting the number of HSCs without impacting cell viability (Petaroudi et al., 2022). The current approaches in expanding HSCs were developed through in vitro technique in recent years by using recombinant cytokines, co-culture methods and small molecules (Bozhilov et al., 2023). However, it is quite challenging to maintain HSCs in vitro as the stem cell survival depends on interactions between cells and paracrine cues from BM microenvironment (Manzo et al., 2022).

The advances of biomaterials nowadays can be seen as contributors towards expansion of HSCs either naturally or synthetic. Petaroudi et al., (2022) mentioned that natural and synthetic polymers made of proteins, polysaccharides, amino acids, apatite and decellularized extracellular matrices have potential in hematopoietic stem and progenitor cells (HSPCs) expansion. Katagiri et al., (2021)

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suggested that chondroitin sulphate (CS), a glycosaminoglycan improve crosstalk interactions between hematopoietic cells and the BM niche after perform experiment towards CS N-acetylgalactosaminyltransferase-1 (T1) knockout mice and wild-type mice. Moreover, potential for HSPCs maintenance and expansion has been demonstrated by both static and dynamic culture conditions in a perfused 3D polyethylene glycol (PEG) hydrogel-based bone marrow and on-a-chip 3D co-culture technique, based on a hydroxyapatite coated zirconium oxide scaffold (Petaroudi et al., 2022). This review aims to summarize and critically evaluate current advances in polymeric biomaterials for the in vitro expansion of hematopoietic stem cells.

MATERIALS AND METHODS

Study Design

The study design that had been chosen for this study was the scoping review method. Scoping studies are a technique for thoroughly mapping evidence from various study designs. This scoping review has been widely used by researchers because they can compare and analyse all the information and data that are related to the selected study or topic. There are researchers that have done their study on the current advances of biomaterials strategies for in vitro expansion of HSCs. Nowadays, this approach can be seen evolving years to years to treat various blood malignancies. Therefore, this scoping review gathers and studies the data or information from relevant papers by exploring and mapping the biomaterials that contribute to expansion of HSCs.

Search Strategy

This scoping review emphasises a relevant scientific publication since it has potential to contribute related information needed. The topic discussed in this research project reflects the fundamentals of science. Therefore, a list of reliable electronic databases such as PubMed, Scopus, Science Direct and Springer Link had been used in this study. The selected journal or article gave ideas within this study and created various outcomes. The precise parameters also been used during the search process to achieve the objectives of the study and answer the research questions. Thus, utilisation of highlighted keywords in this study would be “biomaterials”, “polymers”, “in vitro expansion”, “hematopoietic stem cells”, “bone marrow” and other related words that can assist the research framework. Additionally, the AND and OR which are Boolean operators were used in the keyword search to help discover specific publications and make sure the studies chosen were associated with the research.

Inclusion and Exclusion Criteria

To produce a latest and high quality of scoping review study, there are several criteria that need to be assessed. Inclusion and exclusion criteria are the important parts to determine the article reliability to meet the purpose of the research and consistency in analysing data for scoping review. Hence, several parameters such as pre-review, develop protocol, conduct literature research and manage citations are chosen and considered to select relevant articles for this study. All articles that are not relevant to this study were excluded. In this study, the inclusion and exclusion criteria are shown in Table 1.

Selection Procedures

The selection procedure was based on the Preferred Reporting Item for Systematic Review and Meta-Analyses (PRISMA) guideline (Page et al., 2021). PubMed, Scopus, SpringerLink and ScienceDirect online databases were used to compile all relevant publications, which were then all screened for articles published between 2019 and 2023. The elimination of duplicate articles from various databases was the next step. The chosen papers were then subjected to title and abstract screening in order to find any studies that did not pertain to the study's goals. The remaining papers' full-text articles were then all obtained. Next, remaining articles were read and examined in depth to identify the information regarding the current advances of biomaterials strategies for in vitro expansion of hematopoietic stem cells. During the screening process, any articles that did not match the inclusion and exclusion criteria will be excluded. The selection procedures are displayed in the PRISMA 2020 flow diagram show in Figure 1.

Data Extraction

Data extraction from selected studies involved tabulating relevant information, including author names, year of publication, type of polymeric biomaterials, source of cells, other cells involved in expansion, media culture, rate of expansion, days of culture and mechanism of action. This tabulated data provides a comprehensive overview of factors that influence the in vitro expansion of HSCs.

Table 1: Criteria for Inclusion and Exclusion

Inclusion	Exclusion
Research articles or journal that had been published must be written in English.	Article that does not match with study objectives.
Full text articles must between 2019 until 2023.	Any chapter books, review paper, systematic review or discussion papers.
Research articles whether qualitative or quantitative. Specific keywords must have in the research article.	

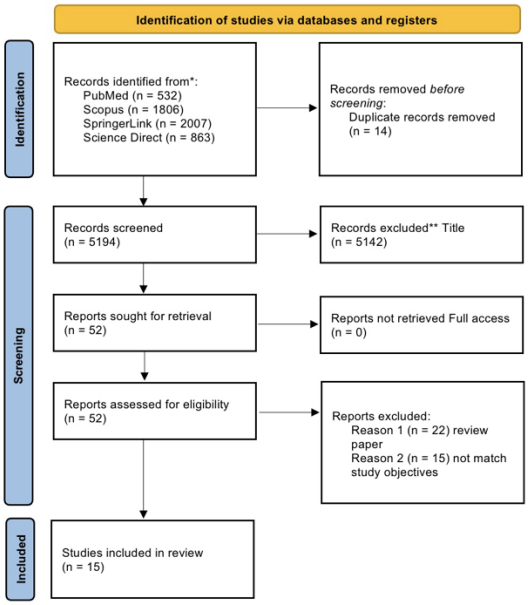

Figure 1: PRISMA flow diagram

RESULTS AND DISCUSSIONS

Based on the searching efforts, a total of 5208 potential articles were identified from the selected databases which are PubMed, Scopus, SpringerLink and ScienceDirect. 14 articles have been removed due to duplicates with similar titles and abstracts. The 5194 articles that left were further assessed for titled and abstract screening. From title and abstract screening, 5142 number of articles had been eliminated because the article did not match the objective of this study which is discussing current advances of biomaterials strategies for in vitro expansion of HSCs and did not consist of the specific keywords in the title and abstract either in the paper. The remaining 52 articles were further screened as all were available to view in full text access. All remaining articles were retrieved and screened for inclusion and exclusion criteria. There were 37 articles that did not match with the inclusion and exclusion criteria and had been excluded because the paper involved review paper and article that did not discuss the usage of biomaterials for expansion of HSCs. Lastly, only 15 articles were selected for scoping review analysis. Table 2 display a list of the titles of the retrieved full-text journal articles.

Table 2: Evidence Table Based on Findings for In Vitro Expansion of HSCs

Authors (year)	Polymeric biomaterials	Source of cells	Other cells involved	Media culture	Rate of expansion	Days of culture	Mechanism
Igarashi et al. (2023)	Polyvinyl alcohol (PVA)-based	HSCs	N/A	O_2 concentration	N/A	28	Optimizing O_2 concentrations, limit the buildup of progenitors and mature hematopoietic cells, thereby improving HSC culture selectivity
Li et al. (2023)	Biomimetic Microniche	HSCs	MNCs	StemSpan™ SFEM II	6.2-folds	7	Generates a suitable cytokine milieu and supplies the appropriate physical scaffolding
Liang et al. (2023)	3D porous gelatin microscaffolds	HSPCs	MSCs	IMDM	N/A	7	Mimicking the structural and mechanical properties (pore size and stiffness)
Manzo et al. (2022)	Alginate-based hydrogel	HSCs	MNCs, MSCs	MyeloCult™ H5100	N/A	21	Resembling BM architecture to improve HSC survival and proliferation, reproduce in

							vitro complex biological same as in vivo cross-talks between stem cells
Marx-Blumel et al. (2021)	3D PDMS scaffold	$CD34^+$ cells	N/A	Stemline® II Hematopoietic Stem Cell Expansion Medium (Sigma Aldrich	N/A	14	Activate key molecular signalling pathways to amplify the numbers of undifferentiated HSCs ex vivo effectively
Miyoshi et al. (2021)	Porous polyvinyl formal resin, Type I collagen	HPCs HSCs	Fetal liver cell, Stromal cells (OP9 and C3H10T1/2)	DMEM	13.9-folds	14	Enhance cell-cell interactions to produce stable performance
Nurhayati et al. (2021)	Alginate-chitosan coating	$CD34^+$ cells	N/A	StemSpan™ SFEM II	94.4 ± 0.4% from 1000 cells	8	The capsules restrict cell growth of MSCs, the $CD34^+$ have enough nutrient/oxygen to release paracrine factor
Sudo et al. (2021)	Hydrolysed polyvinyl acetate	HSCs	N/A	IMDM	1×10^4 $CD34^+$ to 5×10^4 $CD34^+$	7	Support proliferation and expansion of mouse long-term (LT)-HSCs, did not compromise HSC activity after active cell division
Kefallinou et al. (2020)	PDMS and Type I collagen	HSCs	MSCs	Gibco™ MEM α	4.0×10^4 cells/ mL to 8.8×10^5 cells/ mL	8	Resemble the natural in vivo bone marrow microenvironment
Lin et al. (2020)	Wharton's jelly	$CD34^+$ cells	MSCs	DMEM	$0.74 \pm 0.10 \times 10^6$	7	Acts as natural scaffold ex vivo expansion of UCB $CD34^+$ cells and helping to keep them primitive
Miyoshi et al. (2020)	Porous polyvinyl formal resin, Type I collagen coating	HSPCs	Stromal cells	DMEM	6.6-folds to 8.0-folds	14	Support the stimulating factors and cell-cell contact
Zhou et al. (2020)	Alginate-gelatin hydrogel	HSPCs	MSCs	StemSpan™ SFEM II	16.66-folds	14	Mimic the natural conditions for HSPC growth
Arabkari et al.	Polyethersulfone nanofiber	$CD34^+$ cells	MNCs	StemSpan™ SFEM II	9.17 ± 1.06-folds	7	Enhance cell-cell interaction and

(2019)	scaffolds						growth zone
Bai et al. (2019)	3D zwitterionic hydrogel (Polycarboxybetaine acrylamide)	HSPCs	N/A	StemSpan™ SFEM II	73-folds	24	Maintain the HSPCs repopulating ability likes in vivo
Severn et al. (2019)	Porous PolyHIPE foam scaffolds	HSPCs	Neutrophil, Macrophage, MSCs	IMDM	2.85×10^6	28	Mimic the honeycomb architecture of human bone marrow

Comparison of Various Parameters for In Vitro Expansion

Selected articles that have been discussed in this study proved that polymeric biomaterials have ability to support expansion of HSCs. Either natural or synthetic, this approach had shown an effective mechanism in diagnostic settings to treat patients with haematological disorder through HSCs transplantation. Several methods can be seen to create a three-dimensional architecture hydrogel, in which cells can be encapsulated, fibrous scaffolds, 3D printing, or porous materials. Therefore, the chosen parameters which are selection of polymeric biomaterials, selection of main cells, selection of other cells, selection of culture media, rate of expansion, days of culture and optimizing conditions for HSCs expansion could be discuss in depth to identify scientific evidence of current advances of biomaterial strategies for in vitro expansion of HSCs.

Selection of Polymeric Biomaterials

Polymeric biomaterials have been widely used as cell scaffolds because of its beneficial characteristics, which include excellent biocompatibility, biodegradability, and tuneable physical and chemical properties (Hong et al., 2022). Not only that but expanding HSCs through in vitro usually affordable compared to in vivo method that require animal culture. By constructing a 3D scaffold, it became the most effective tool for simulating biological microenvironments that necessary for stem cell augmentation and proliferation. All studies used polymers to expand HSCs. This is because polymers have potential to provide scaffold for HSCs likely in natural human body. This condition gave HSCs interested to expand despite outside the natural environment. Mostly, the studies used synthetic polymers such as PVA, PDMS, PES and modified zwitterionic as the scaffold (Marx-Blümel et al., 2021; Sudo et al., 2021; Bai et al., 2019). Unlike Nurhayati et al., (2021) and Zhou et al., (2020), they used natural polymers which are alginate-chitosan and alginate-gelatin, respectively. These natural polymers show no effect on gene expression, surface marker integrity, or cell viability. Clearly, polymers-based design has significant applications in tissue engineering and beyond. The 3D zwitterionic hydrogel design by Bai et al., (2019) show a reliable expansion which is 73-folds. The establishment of hydrogels in three-dimensional gave a better resemble BM niche by producing a hypoxic gradient that is seen naturally in the marrow (Liu et al., 2022). Despite that, Wang & Sugimura, (2023) mentioned that it is critically important to comprehend the molecular mechanisms and physio-chemical parameters of the bone marrow niches to reconstruct and duplicate the HSC proliferation in bone marrow.

Selection of Main Cells

Along this study, six out of fifteen used HSCs thus indicates the major stem cell sources for cells-based therapy that have shown good efficacy. HSCs commonly reside in several area such as peripheral blood (PB), bone marrow (BM) and umbilical cord blood (UCB). HSCs provide benefits such as increased tolerance to variations in the human leukocyte antigen (HLA) and reduced burden of donor (Sakurai, 2023). It is also having primary benefits over other stem cells like quick sample availability, low risk of infection transmission, and relatively simple procurement process (Derakhshani et al., 2019). In contrast, there were also five studies focus on usage of HSPCs as their source of cell. The interaction of HSPCs with the ECM seems also could mimic porous architecture of cancellous bone, which harbours the niche-harbouring red BM (Chatterjee et al., 2021). In addition, four studies used CD34+ cells as their source to undergoes expansion. This surface marker easily obtains from human BM as it presents both in HSCs and HSPCs.

Selection of Feeder Cells

Eight out of fifteen studies chose MSCs or known as stromal cells as their main option for co-culture with HSCs. According to conventional methods, HSCs often need a feeder cell layer to sustain quiescence and pluripotency. In fact, MSCs and HSCs are naturally resided in BM niche to maintain their physiological behaviour. Biologically, MSCs are dynamic, they develop into a variety of lineages that further make up the niche needed for the preservation of HSCs. Chatterjee et al., (2021) also claimed that clinical

studies have shown that co-culturing human HSPCs ex vivo with MSCs boosted their expansion without compromising their stemness and greatly enhanced patient engraftment after transplantation. Thus, it is crucial to make sure that the co-culturing process align with in vivo environment thus it can give positive results. Apart from that, there were also four studies chose white blood cells such as macrophage, neutrophil and MNCs as the feeder cells to aid expansion of HSCs. According to Li et al., (2023), the culture of HSCs and MNCs demonstrate positive outcome for xenograft assay as the expansion remain HSCs morphology and viability. This suggested that potential application in xenograft experiment could retain the cultured cells. Interestingly, five out of fifteen studies conduct their culture without adding any cells. Despite that, there were still an expansion of HSCs if the paracrine signalling occurs among the cells. The HSCs can communicate with one another through paracrine signalling, in which signalling molecules are released and bind to nearby cells to activate them.

Selection of Culture Media

Throughout the review, five out fifteen studies show that the main media which is StemSpan™ SFEM II used to expand in vitro HSCs. StemSpan™ SFEM II support the expansion of normal or leukemic human HSPCs or their lineage-specific differentiation when added with hematopoietic growth factors or other stimuli. StemSpan expansion supplements are pre-mixed cocktails of recombinant human cytokines and other additives. Thus, it believed that this media able to encourage the expansion with the designed technologies. Besides that, three studies conduct the culture trial by using DMEM as their media. DMEM was originally formulated with low glucose (1 g/L) and sodium pyruvate, but is often used with higher glucose levels, with or without sodium pyruvate. It contains no proteins, lipids, or growth factors. Therefore, it requires supplementation, commonly with 10% Fetal Bovine Serum (FBS). Thus, DMEM plays an important role by providing nutrients to the HSCs. Apart from that, three studies prefer to use IMDM for their culture media. IMDM is a modification of DMEM that introduces selenium and other amino acids and vitamins. IMDM offers rapid proliferation and is appropriate for high-density cell cultures to support expansion of HSCs.

Rate of Expansion

Throughout extraction of data from all papers included in this study, the expansion method by Bai et al., (2019) shows the highest outcome compared to others. The authors used combination of polymers and hydrogel to mimic the natural microenvironment. Therefore, the HSCs may recognize the in vitro conditions same as in vivo niche. Interestingly, in this three-dimensional (3D) zwitterionic hydrogels, an increase in long-term (LT)-HSC growth of 73-folds was recorded after 24 days. The corresponding in vivo outcomes showed that the enlarged HSCs could restore the haematopoiesis for a minimum of twenty-four weeks in immunocompromised mice. Other than that, the rate of expansion after 7 days depicts a satisfy outcomes where the folds changed from initial number. This indicates that the designed scaffold has potential to supplies reliable condition for HSCs to expand. The rate of expansion after 7 days can reach 6.2-folds according to Li et al., (2023). Meanwhile, the studies show a higher rate of expansion after 14 days for instance 13.9-folds, 8.0-folds and 16.66-folds. This indicates that the when the culture period increases, the rate of expansion increases.

Days of Culture

Five out of fifteen studies indicate the shortest period of culture which is 7 days to obtain an increased number of HSCs. This indicate that the approach used very efficiently as combination of selected polymeric biomaterials comply in vivo conditions. This suggests that the expansion of HSCs is not impossible to achieve within 1 week even in vitro settings. However, there were studies require 14 days to complete the culture. After that, it shows that a satisfactory result as the rate of expansion achieve 13.9-folds (Miyoshi et al., 2021), 8.0-folds (Miyoshi et al., 2020) and 16.66-folds (Zhou et al., 2020). Interestingly, Bai et al., (2019) require 24 days for their culture and obtain very satisfying result which is 73-folds of HSCs expansion. It is quite outstanding approach as the culture does not involve other cells to support expansion of HSPCs. Finally, two studies require 28 days representing the longest culture period for expanding HSCs. It cannot be denied that the expansion still possible to sustain as the outcome indicate a positive response after long period (Igarashi et al., 2023; Severn et al., 2019).

Optimizing Conditions for HSCs Expansion

This review highlights that most trial focus on to mimic and resemble the structural and mechanical properties of BM niche. This due to provide a conducive environment towards HSCs to undergoes expansion. This mechanism can be achieved by building of polymers that align with the condition of BM niche thus it will lead to natural scaffolding that help to keep HSCs in primitive. In contrast with Igarashi et al., (2023), they aim to optimise O2 concentrations as the conditions should be in hypoxic. This mechanism restricts HSCs to become mature cells rapidly as it should be expanded at the first place. Other than that, several trials have done by enhancing cell-cell interactions in cultured scaffold. This mechanism guarantees HSCs to expand in presence of MSCs or MNCs

for activation of molecular signalling pathways. Hence, a stable performance can be achieved as well as support HSCs in vitro effectively.

Summary of Findings

The studies here demonstrated creation and sustainment of the 3D bone marrow is the most important and encouraging factor for the subsequent HSCs expansion. The combination of various parameters will support and provide the essential nutrients for the HSCs development and maintenance. These are promising results to be subsequently applied on future approach in vitro expansion of HSCs. The suitable polymeric biomaterials could resemble the architecture of BM niche and enhance cell to cell interaction. The HSCs should be bonded to reliable feeder cells such as MNCs and MSCs to facilitate a faithful cellular microenvironment. Most importantly, the consistency of renewing or changing culture media for in vitro expansion of HSCs will promise positive formation of cell in certain period. Hence, the HSCs expansion in 3D technique holds promise for researchers to achieve continuous solution in treating various blood disorders.

CONCLUSION

In conclusion, this scoping review study showed that polymeric biomaterials can improve the expansion of HSCs by ensuring right culture technique. The development of sophisticated cell treatments for bone marrow transplantation and various blood diseases has made the expansion of HSCs a crucial objective. The comparison of various research in five years range proved that there was a potential to stabilise and expanding HSCs in laboratory settings. Thus, the objectives of this study have been achieved as it was able to identify type of polymeric biomaterials that support in vitro expansion of HSCs. Other than that, this study also manages to determine the contributing parameters that assist stabilisation of polymeric biomaterials towards expansion of HSCs. Improvement has been made possible by using effective polymers, useful feeder cells and right culture technique. 3D structures have frequently taken the role of 2D cultures as study models because they appear to be particularly important for maintaining as much of the original system as possible, including avoiding polarization or phenotypic changes as well as gene expression adjustments. Therefore, comprehension of HSCs behaviour in culture and their reaction to artificial niche signals may aid in the success of their in vitro expansion in 3D scaffolds. Not only that but this study could become advances solution in resolving blood shortage. The mobile donation can be reduced by providing a flexible human HSCs expansion strategy with considerable application potential. To fully understand the efficacy and safety of this mechanism, more research is necessary, and they should be taken with a various potential strategy. It will be fascinating to see if these various strategies work well together and enhance HSCs proliferation and stability in vitro.

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ORIGINAL ARTICLE

The Current Provision of Post-Stroke Vision Care in Malaysia: A Qualitative Interview Among Stroke-Care Professionals

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ABSTRACT

Background: The inequality in care provision for stroke survivors who have visual problems has been reported globally. It revealed that many stroke survivors continue to experience unmet needs concerning their visual problems. Qualitative interviews were conducted with stroke care professionals to explore gaps and loopholes in vision care provisions. **Methods:** A semi-structured interview study using purposive sampling and inductive qualitative content analysis was conducted. A total of 8 stroke-care professionals with more than 10 years of experience from university teaching Hospitals in Malaysia were recruited for the interview from January 2021 to January 2022. A criterion-based sample of healthcare professionals involved in post-stroke care was recruited. Data collection continued until thematic saturation was reached. Ethical approval has been obtained from the IIUM Research Ethics Committee following the principles of the Declaration of Helsinki. **Results:** The central theme is current provision, and there are five main themes identified: indefinite vision care pathways, incomplete eye examination, insufficient referrals, absence of visual rehabilitation, and lack of eye care professionals. All respondents reported that the most common visual impairments seen in their practice were homonymous visual field loss and visual neglect. However, the care pathway for assessing visual impairment remained unclear and varied among professionals. In outpatient services, rehabilitation mainly focuses on improving bodily function and activities of daily living. There is also a need to include optometrists and ophthalmologists specializing in neuro-vision care in the rehabilitation team. **Conclusion:** This study shows that there are gaps and loopholes in the current provision of post-stroke vision care in Malaysia. A standardized protocol in the country should be developed to give a clear pathway for managing vision after a stroke.

Keywords:
Visual Impairments, Post-Stroke Vision Care, Visual Care Pathway, Optometrist

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INTRODUCTION

Globally, stroke is a major cause of mortality and disability (Johnson et al., 2019). In 2019, the Global Burden of Disease has reported that there were 101 million prevalent cases of stroke, 12.2 million incident cases of stroke, and 6.55 million deaths from stroke. Stroke remained the second-leading cause of death and the third-leading cause of death and disability-adjusted life years (DALYs) in 2019 (Feigin et al., 2021).

Many studies have been conducted in Malaysia aimed at improving the care of patients with stroke (Cheah et al., 2016). However, none of the studies to our knowledge have specifically reported on the post-stroke vision problems and care among stroke survivors. Thus, the prevalence of visual impairment after stroke in this country is unknown and underreported. Abnormalities of central and/or peripheral vision, eye movements, and a variety of visual perception problems, such as inattention and agnosia, are examples of visual impairment that can affect the visual function of stroke patients (Pollock et al., 2012).

The most common visual symptoms were blurred or altered vision (22.1%), visual field loss (12.6%), diplopia (9.9%), and reading difficulties (9.7%) (Hepworth et al., 2021). In one study, 703 were identified to have a new visual impairment, and 47.1% reported visual symptoms. No visual symptoms were reported by 38.4%, and 14.5% were unable to report symptoms (Hepworth et al., 2021). Stroke survivors may or may not have visual symptoms, i.e., the patient reports the effect of their visual impairment (Pollock et al., 2019).

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The inequality in care provision for stroke survivors who have visual problems has been reported in the UK (Rowe et al., 2015). It reports that many stroke survivors continue to have unmet needs regarding their visual problems. In Malaysia, there is no study regarding vision care for post-stroke patients. Thus, the objective of the present study is to investigate the current vision assessment and management and rehabilitation of stroke survivors among professionals. The main research question of the study is on the current provision of post-stroke vision care in Malaysia, investigating the gaps and loopholes in the current provision of post-stroke vision care and how effectively the current available protocol and tools help the post-stroke patients in managing their vision.

MATERIALS AND METHODS

This study is a descriptive qualitative study that investigates gaps and loopholes in the current provision of post-stroke vision care in Malaysia. The research methods and the reporting follow the Consolidated criteria for reporting qualitative research (COREQ; Tong, Sainsbury & Craig, 2007). Any research material related to the study is available from the corresponding author.

Eight stroke-care professionals (2 neuro-ophthalmologists, 1 Neurologist, 2 Rehab-Physicians, 2 Geriatricians, and 1 Emergency Physician) from Teaching University Hospitals in Malaysia were recruited for the interview (see Table 1). Our participants were selected by purposeful sampling. Sampling decisions were made a priori based on reasonable criteria rather than theoretical saturation (selective sampling). Based on our research question, the following factors were found to be varied: professional group, discipline, and care setting. A criterion-based sample of healthcare professionals involved in post-stroke care was recruited. Data collection continued until thematic saturation was reached. The relevant professional groups and care settings were identified by the author concerning the Stroke Clinical Practice Guidelines 2020. At least one representative was included. Criteria for inclusion are as follows (1) representative of one of the defined professional groups and care settings; (2) in a leading position with major responsibilities (e.g. senior physician, medical director, and head of department): (3) special interest in the research question. This corresponds to common definitions of persons with special expertise (Morse, 1994). Exclusion criteria were as follows: (1) no interest in the research question.

Table 1: Profile of the stroke-care professionals

Initial	Age	Gender	Year of experience	Designation
Dr A	60	Male	35	Neuro-Ophthalmologist
Dr B	57	Male	35	Neuro-Ophthalmologist
Dr C	39	Female	12	Geriatrician
Dr D	50	Female	25	Rehabilitation Physician
Dr E	44	Male	18	Emergency Physician
Dr F	44	Female	18	Neurologist
Dr G	48	Male	15	Rehabilitation Physician
Dr H	41	Male	18	Geriatrician

Data Collection

The first author (E.A.) contacted participants by informing them via email about the study background, methods, and data protection, and gave written or verbal consent to their participants. Personal interviews were conducted following a semi-structured interview guide, which was conducted in English. The resulting interview guide was discussed and developed based on references by Rowe et al. (2022). The interviews were conducted from Jan 2021 until Jan 2022 by the first and second authors (E.A.) and (A.M). All interviews were audio-taped and transcribed verbatim. Words or phrases stressed by the interviewees were transcribed in capital letters. The transcripts were not returned to the participants to avoid censoring and corrections. Although member checking was not undertaken, credibility was strengthened through an audit trail, reflexivity, peer debriefing among research colleagues, and data triangulation (Braun & Clarke, 2022). These strategies enhanced methodological transparency by documenting analytic decisions, ensuring interpretations were grounded in participants' data, and providing sufficient contextual detail for readers to assess trustworthiness (Braun & Clarke, 2019). The study protocol and materials have been reviewed and approved by the IIUM Research Ethics Committee (IREC 2022-091).

At the beginning of each interview, the objective of the study was explained to the participant. The research aims to explore the current provision of post-stroke vision care in Malaysia among stakeholders and find gaps and loopholes in this provision. Participants were then asked questions related to their practice and experience with the current practice. The four questions that were asked in this research are visual problem, visual care pathway, current provision, and management (Appendix 1). At the end of

the interview, participants could add anything else they found related to the current post-stroke vision care. Personal information was collected on the participants' age, gender, and years of professional experience since graduation, their profession, and additional training or qualifications. The interview took between 20 and 60 minutes.

Data Analysis

The interviewer analyzed the transcripts using macroanalysis and microanalysis, open coding, and thematic analysis (see Table 2 and 3). We extracted all information referring to our research question and summarized it into categories, checking back with the original data.

Macroanalysis examines data at a broader level (categories), and microanalysis is more detailed and line-by-line in data (initially coded and subthemes) (Braun & Clarke, 2022). ATLAS.ti (CAQDAS) that helps organize, code, retrieve, and interpret qualitative data systematically.

The resulting categories were then organized into five main categories (indefinite vision care pathways, gross eye examination, insufficient referrals, absence of visual rehabilitation, and lack of eye care professionals' involvement). Content, coding rules, and prototype examples were defined for each category to increase transparency and reliability (Pope, Van Royen & Baker, 2002). Two researchers (E.A. and A.Z.) first analysed the interview separately. Consensus was reached, and if necessary, the codebook was adapted. The remaining interviews were coded by one of the two researchers and checked by the other researcher. Discrepancies were discussed until consensus was reached. Results, progress, and data saturation were discussed during the process (Lotz et al., 2015).

Table 2: The structure of open coding

Raw Data (Quote)	Initial Code	Category/ Subtheme	Theme
"So usually, its just by clinical examination, for example hemianopia just do cancellation test and phenol red dot test. So, if we detect it, normally we will refer to Ophthalmology for a proper charting. There are no local or or international care pathways available''	No standard pathway	General visual outcome/not specific	Gross Eye Examination

Table 3: The process of open coding

Example of data	Its just picked up at clinical examination. So for diplopia actually there is nothing. For neglect at least we refer to Ophthalmologist and they will do the charting. I forgot the name of the chart to actually quantify the visual field. If it is neglect also we tend to use the general visual neglect outcome measures or scales but that one is not specifically for visual neglect. Only looking at general aspect	Ya, that's why we don't have that much for vision. For physical therapy, I don't think that much. But some physical therapy they are also aware to do on scanning. Most of it will be done by occupational therapist. Again, it is mainly compensatory and stimulation. They are not trained and we used to have one or two training for low vision rehab but that also is very basic so basically if its low vision rehab also sometimes, we will refer back to other NAD? Or other cases
Initial codes	General General visual outcome/not specific	Basic Examined or trained by non-professionals
Initial sub-themes	Gross Eye Examination	Lack of Eye Care Professionals' Involvement

RESULTS

After 8 interviews, a few new codes and themes emerged from the data. Therefore, we decided to stop further recruitment of participants. The 8 participants were from a teaching university hospital. The participants consisted of 8 professionals with stroke (5 men and 3 women) with a mean age of 64 years (SD = 15) and an average of more than 10 years of experience.

Thematic Analysis

The themes that explain the current provision of post-stroke vision care were 1) Indefinite Vision Care Pathways with two categories which are varied care pathways and non-standard protocols 2) Gross Eye Examination with three categories which are lack of comprehensive eye examination, assessment based on patient complaint and insufficient information regarding visual impairment; 3) Insufficient referral with two categories which are lack of coordination between healthcare providers and absence of multidisciplinary approach; 4) Absence of visual rehabilitation focusing on visual rehabilitation and basic education/training among physicians; 5) Lack of Eye Care Professionals Involvement which are non-involvement of Optometrist and Ophthalmologist in emergency and ward and insufficient expert on visual rehabilitation. Table 4 illustrates the identified Themes and Categories.

Table 4: Themes and Categories of the current provision of post-stroke vision care

Themes	Categories
Theme 1 Indefinite Vision Care Pathways	Varied care pathways Non-standard protocols
Theme 2 Gross Eye Examination	Lack of comprehensive eye examination Assessment based on patient complaint Insufficient information regarding visual impairment
Theme 3 Insufficient Referrals	Lack of coordination between healthcare providers Absence of multidisciplinary approach
Theme 4 Absence of Visual Rehabilitation	Focusing on physical ability Basic education/training on visual impairment among physicians
Theme 5 Lack of Eye Care Professionals Involvement	Non-involvement of Optometrist and Ophthalmologist in emergency/ward Insufficient expert on visual rehabilitation post-stroke

Theme 1: Indefinite Vision Care Pathways

This theme refers to the current management strategies that are available for stroke patients who are experiencing vision loss or visual impairments. Varied care pathways among professionals within a healthcare system, depending on their current protocol and preferences. There are no standardized post-stroke vision care pathways to be followed by professionals. The non-standardization of care pathways leads to confusion and reduces the quality of life in stroke patients' care, and also reduces efficiency in the management.

…So usually, it's just by clinical examination, for example hemianopia just do cancellation test and phenol red dot test. So, if we detect it, normally we will refer to Ophthalmology for a proper charting. There are no local or international care pathways available… (G, Dr)

…So far no. We will handle with what we usually do. Unless patient request for anything extra, patient will go and seek by themselves. Because we are the referral centre already. Limited resources here… (H, Dr)

Currently, the protocol for post-stroke vision care is non-standardized. Clinical Practice Guidelines for the Management of Stroke 2020 (CPG 2020) stated that confrontation is the only method to detect any visual impairment in post-stroke patients which is insufficient and not addressing the possible visual impairments.

…In the emergency unit, only physical examination, which is confrontation. I am not sure in terms of the pathway for visual impairment when the patient is in the ward… (E,Dr)

Theme 2: Gross Eye Examination

Gross eye examination limits its ability to fully evaluate the

extent of vision impairments and the specific needs of stroke patients. Gross eye examination also limits the sensitivity and specificity of the diagnosis. Lack of comprehensive eye examination can lead to misdiagnosis and may delay the recovery and rehabilitation of the visual impairment.

…It's just picked up at clinical examination. So, for diplopia actually there is nothing. For neglect at least, we refer to Ophthalmologist and they will do the charting. I forgot the name of the chart to actually quantify the visual field. If it is neglect also we tend to use the general visual neglect outcome measures or scales but that one is not specifically for visual neglect. Only looking at general aspect… (G, Dr)

…Because if we assess through clinical examination such as confrontation is not accurate. We can get rough estimation but not accurate… (A, Dr)

Assessment based on patient complaints were reported by the geriatrician, neurologist, and also rehabilitation physician. If one complaint were made by patients, then only the related department will refer for further assessment. However, visual symptoms are frequently poorly described by patients, particularly where individuals have coexistent communication and cognitive impairments (Hepworth et al., 2015).

…As a comprehensive check, we will check the vision but if they only present visual impairment, if junior doctor examined they might miss the sign of stroke. If it is only visual impairment because they might think that as other ophthalmological problem. So, then the awareness has to be more. There is benefit if either the doctor, staff or patient aware that visual impairment can be part of stroke presentation… (Dr D)

Insufficient information regarding stroke and visual impairment among patients was also reported by professionals because patients usually did not complain and did not aware if the symptoms they have is related to vision.

…First challenge is awareness among the patient. One is about stroke. Then if they can recognize the stroke, emergency of the stroke such as if the patient comes fast to emergency. Like I said there is a window treatment. Third, awareness regarding our stroke centre. They will go nearby hospital instead of stroke centre. Fourth, it is a university hospital, not KKM… (Dr E)

Theme 3: Insufficient Referrals

There is a lack of coordination between healthcare providers. When coordinated care is absent, each healthcare provider might not be aware of each other's assessments and treatment plans, which could lead to misdiagnosing. For example, a patient might see a general neurologist who focuses on neurological recovery but does not communicate or there is no service for a neuro-ophthalmologist, meaning visual issues like hemianopia or visual neglect might go unnoticed or untreated.

…Usually the management is just assessed and most of the patient has diabetes is just follow up on that. There is no real advice on visual field or visual neglect on how to rehabilitate or any guideline from that. So usually, honestly, we will refer so if what happens also did not really matter to us. Even from patient's point of view also we do not really educate the patient that much. We just assess, tell the patient's condition and it may recover or not recover its just wait and that's it. There is no real or active therapy on their side… (B, Dr)

The absence of a multidisciplinary approach in post-stroke vision care can limit the recovery and efficiency of the treatment for stroke patients who have visual impairments. Visual impairment caused by strokes involves neurological, ophthalmological, and rehabilitative issues. All professional disciplines are important to be coordinated so the patient may receive comprehensive, integrated care that can address the suitable management.

…So, to be honest for visual perception, visual neglect and stuff are something that we read about but we do not really practise. Again, in Malaysia it is very limited to refer to. We are supposed to start our low vision clinic but we have not started yet. Our occupational therapist is sent for training but I think they are not comfortable to do it. Like, for stroke in terms of stimulation for Ophthalmoplegia, it's a bit more on visual neglect but it is more on compensatory method approaching from affected side and using bright light or photos and ophthalmoplegia. I will ask him on function like looking left, looking right and find to follow object. There is no real therapy where you can measure the outcome. Ideally you can actually measure, do it and measure again. And see if its good or not… (D, Dr)

Theme 4: Absence of Visual Rehabilitation

Focusing on physical ability but not visual rehabilitation in post-stroke patients can negatively impact stroke survivors. Especially to those with visual impairment after strokes. Visual impairments after stroke can significantly affect a person's ability to be independent and have a better quality of life. When health care professionals ignore the importance of visual rehabilitation, it can lead

to long-term disability and diminished recovery in stroke patients. It will also hurt cognitively and emotionally.

…Yes, if it is diplopia, it can cause visual problem and also hemianopia. The main thing that I worry about is falls. If they have stroke, and they are walking, the balance and power is not so good. On top of that, any visual problem will cause functional issue, easier to fall, and for neglect, like eating and day to day activities… (D, Dr)

Only basic training on visual impairments was provided to the majority of the professionals. It is a critical issue as it can hinder recovery. Visual impairments can go unnoticed if professionals in healthcare lack the required knowledge and skill for visual rehabilitation.

…Yes, just a basic clinical exam, cranial nerve check, visual acuity, like the patient standing away from the chart and just read of the lines… (D, Dr)

Theme 5: Lack of Eye Care Professionals' Involvement

The non-involvement of optometrists and ophthalmologists in emergency/ward can also hinder the timely diagnosis and treatment of vision problems that the stroke survivors experience. As visual impairment is a common consequence of stroke, stroke survivors must receive appropriate care, and the visual professional to be in the team to make an appropriate diagnosis and referral for further assessment or therapy (Rowe et al., 2020).

…Ya, that's why we don't have that much for vision. For physical therapy, I don't think that much. But some physical therapy they are also aware to do on scanning. Most of it will be done by occupational therapist. Again, it is mainly compensatory and stimulation. They are not trained and we used to have one or two training for low vision rehab but that also is very basic so basically if its low vision rehab also sometimes, we will refer back to another NAD? Or other cases… (F, Dr)

…Yeah, I think that will be helpful. Like I said, it mainly just the doctors who do the clinical examination to pick up such conditions, and formal visual acuity tests are not done. Unless the patient complains that their visual acuity is different than before, and I said for retinopathy, funduscopy can also be done… C, Dr)

Currently, in the country, there is an insufficient number of experts on visual rehabilitation post-stroke. Optometrists and ophthalmologists are encouraged to equip themselves with the knowledge in visual rehabilitation as we have a shortage of expertise in this field.

…Ya, so if it is neglect, of course we can here be we do a lot of stimulation from the affected side. If it is diplopia, we get our occupational therapist to teach some compensation method. Either eye patching and everything if it is severe. If it is neglect also we will teach visual scanning or head turning or scanning. Those are compensatory mechanism and there is no real eye therapy for that. I mean if there is ophthalmoplegia, the most we get to do is to get the patient to practise moving or looking object up, down, left and right. Recently, I think through Prof M's contact, Neuro-Optometrist has joined us for certain prism and assessment…(Dr D)

DISCUSSION

This qualitative research aims to investigate the current provision of post-stroke vision care among professionals involved in treating stroke patients. We study the current practice in visual perception screening and also related eye examinations. The challenges faced by health care professionals were also being studied. The biggest challenges faced by our participants were the non-standardized protocol and lack of expertise.

National Clinical Guidelines for Ischaemic Stroke (CPG 2020) recommend that every stroke survivor who appears to have visual impairment be checked with a confrontation test (Malaysian Society of Neurosciences, 2020). The National Institutes of Health Stroke Scale (NIHSS) was used in the emergency department and the ward. Again, the only visual check is confrontation, which is insufficient and inaccurate. No standard protocol related to vision was mentioned by the participants, except CPG 2020 and NIHSS. After a patient is discharged from the ward, follow-up depends on the severity of the complaints and the patient. Eye examination is not compulsory.

Visual impairment among stroke patients is an under-recognised problem that can cause a significant impact on the quality of life of stroke survivors. All professionals should be aware that visual problems are common to happen in stroke survivors (Rowe, 2016). In the emergency department, visual outcomes of acute central and branch retinal artery occlusions are poor, and acute treatment options are limited by delayed diagnosis (Bénard-Séguin et al., 2024). Retinal optical coherence tomography (OCT) is more detailed and useful in diagnosing compared to normal ocular fundus. But it is seldomnly available in ED (Bénard-Séguin et al., 2024) One study found out that non-mydriatic ocular fundus fundus photography (NMFP) combined with OCT are powerful and can accelerate the detection of early retinal ischaemia. This eye stroke protocol can allow rapid intervention but the education is

also important among professionals in healthcare department regarding acute vision loss among stroke survivors (Bénard-Séguin et al., 2024).

In rehabilitation management, treatment options aim to restore visual function to as normal as possible. Increasing ageing population will result in more stroke survivors requiring rehabilitation and with high prevalence of stroke survivors at a younger age, who are still in working fields, more survivors requiring rehabilitation. Policy makers need to understand the importance of providing post-stroke rehabilitation services including visual functioning (Rowe, 2016). Most of the professionals reported that the condition of the patient is the barrier for standardised assessment (Vancleef et al. 2020). Many tests not designed and not suitable for stroke survivors with aphasia and/or dysarthria (Vancleef et al., 2022)

In hospital settings, FAST helps recognize common stroke signs like Face drooping, Arm weakness, and Speech difficulty, but it may miss visual symptoms. BE FAST adds Balance and Eyes, highlighting that sudden blurred, double, or lost vision can also signal a stroke, especially in the posterior brain. Including Eyes in BE FAST ensures that vision-related strokes are recognized quickly for faster treatment for anterior ischaemic stroke (Tanglay et al., 2024).

The establishment of a visual team is important in the stroke unit. Early assessment and registration of the patient's visual symptoms is needed to provide necessary rehabilitation (Norup et al., 2016). Visual impairment after stroke is common. From a study, about one-quarter of the patients had some kind of visual deficit after stroke (Norup et al., 2016). The majority of the professionals in this study agreed that it is important to involve an Optometrist and Ophthalmologist in the stroke team. It is even more necessary to have a neuro-optometrist in the team to be involved in visual rehabilitation.

A limitation of this study is that participants were recruited from a single tertiary hospital, which may limit the transferability of findings to other settings. Additionally, the sample size was purposively selected, which may not capture the full range of professional perspectives. Despite these limitations, the study provides in-depth, contextually grounded insights into the professional experiences of healthcare providers, which can inform practice, policy, and future research in similar settings.

CONCLUSION

Several gaps and loopholes need to be addressed in current post-stroke vision care among professionals. Standardized protocols need to be implemented to ensure that all professionals deliver comprehensive care, specifically for visual issues. Visual team, Optometrist and Ophthalmologist to be involved as early as in acute care. Continuous training and knowledge about post-stroke vision care among professionals are crucial to avoid misdiagnosis of the visual impairment.

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APPENDIX 1

Pre-coded Qs:

1. What type of visual problem (after stroke) seen?
2. How are these identified?
3. How are these treated and follow-up?
4. What care pathways are used? Any designated care pathway (local/international)
5. What type of visual impairment (visual conditions recognized by the professions)?
6. Are there any options of treatment; personal treatment or referred?
7. Is there any links with other professions and referral options?
8. What is the stroke related general impairments?
9. What is the impact of visual problems?
10. What variable time patients were seen?
11. Is there any screening form used?
12. What is the frequency of visual conditions?
13. Are there various treatment options offered?
14. Are there any patients had no visual symptom but had an eye condition?
15. Have you been trained for an eye exam?
16. What is the scope of treatment for stroke patients?
17. What services are offered?