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Impact of a nutrient-rich health bar intervention on health and cognitive performance among children and adolescents in the B40 community in Gombak

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Abstract

Diet and nutrition are vital in preventing cognitive decline, yet research on their impact on children and adolescents, particularly in Malaysia, remains limited. This study evaluated the effects of a health bar intervention on the health and cognitive performance of children and adolescents from the B40 community. A health bar formulated with date powder, moringa, sacha inchi oil, and pumpkin seeds was assessed for acceptability and efficacy. Seventy participants aged 10–16 from two boarding schools underwent an eight-week intervention, during which anthropometric measurements, PedsQL 4.0, and RAVLT were used to evaluate health and cognitive outcomes. The results revealed significant improvements in physical health, emotional well-being, and mental performance, particularly among males, highlighting the influence of socioeconomic factors on nutrition and cognition. Overall, the health bar intervention led to significant improvements in physical health and cognitive function, suggesting the need for extended study durations and diverse data collection methods for future research.

1. Introduction

Diet and nutrition are well-established modifiable factors that influence the early prevention and delayed progression of age-related cognitive decline (Kristo *et al.,* 2020). Extensive epidemiological research highlighted their crucial role in improving long-term cognitive function (Malek Rivan *et al.,* 2022). Many may concur with the fundamental principles regarding the relationship between food and learning: (1) that consistently consuming an adequate, high-quality diet supports cognitive enhancement; (2) that a nutritious diet is associated with better cognitive function; and (3) that malnutrition, widespread among economically disadvantaged adolescents, is linked to reduced cognitive abilities.

However, despite the widespread acknowledgement of food's importance in learning, empirical research on the precise relationship between overall diet and cognitive achievement in children and adolescents remains scarce. There have been numerous documentations of infants and young children's health and nutritional status in less developed countries, but little attention has been given to the condition of older children. Children and adolescents' health and nutrition in Malaysia have not received much attention, as indicated by the relatively little published information on this topic, primarily in urban areas. Suzana *et al.* (2019) elucidated that the health and nutritional status of those living in the urban sector has been neglected, as the focus has mainly been on people with low incomes and the hardcore poor households in the rural areas of Malaysia. These children and adolescents have been the least studied in evaluating a community's cognitive performance and health status, since they are assumed to be less at risk of being malnourished or having poor health. However, it is known that poor nutrition is associated with poor cognitive performance (Spencer *et al.,* 2017).

Incentives given by policymakers to overcome the issue include a supplementary food programme that helps meet the needs of children and adolescents (Kim & Kang, 2017). The menu selection for this programme is mainly based on the nutrient contents that promote good health and well-being of the children and adolescents (Vilar-Compte *et al.,* 2021). Given this backdrop, this study decided to choose a health bar as part of the food intervention programme due to the components of its ingredients, which are beneficial in promoting human health. The health bar had been developed in a previous study, and its

nutrient content had been determined (Mohd Noor *et al.*, 2024).

Meanwhile, this study had two main objectives: first, to investigate participants' acceptability towards the health bar; second, to assess the improvement of health and cognitive performance of the participants after the intervention. It was hypothesised that regular consumption of the health bar would lead to significant improvements in physical health indicators and cognitive test scores. The health bar has the potential to improve cognitive performance and overall health due to its combination of functional ingredients—date powder, Sacha Inchi (*Plukenetia volubilis*) oil, Moringa (*Moringa oleifera*) powder, and pumpkin seed—each known for its neuroprotective and brain-boosting properties. Dates are rich in ferulic acid, an antioxidant that helps protect against amyloid-beta (αß) fibrils, enhancing learning and memory, improving cognitive flexibility and reversal learning of left-right discrimination (Subash *et al.*, 2015). Sacha inchi oil supports brain function by increasing theta, alpha, and beta brainwaves, which activate the inferior frontal cortex, enhancing cognitive performance in areas such as memory and attention. Moringa (*Moringa oleifera*) contributes vigorous antioxidant activity through its high flavonoid and phenol content, reducing oxidative stress by inhibiting lipid peroxidation (Brilhante *et al.*, 2017). Furthermore, moringa leaf extract promotes neuroprotection by enhancing neurite outgrowth and increasing the number and length of dendrites and axonal branches in hippocampal neurons (Hannan *et al.*, 2014). Pumpkin seeds, rich in magnesium and zinc, are known to support children with learning disabilities; magnesium improves oxygen transport to cells, boosting focus and task attention, while zinc aids memory by facilitating neuron communication in the hippocampus (George, 2014; Hoane, 2011).

2. Materials and methods

2.1 Materials

The health bar formulation incorporated several key components, including exceptionally functional ingredients. Date powder, Sacha Inchi (*Plukenetia volubilis*) oil, and Moringa (*Moringa oleifera*) powder were sourced from local manufacturers in Selangor. The core structure of the health bar, consisting of bubble rice, pumpkin seeds, and oats, was procured from a manufacturer in Klang, Selangor. Furthermore, Beryl's dark chocolate compound and sugar alcohols (maltitol and isomalt) were used as coatings for the health bar.

2.2 Methods

2.2.1 Acceptance test (5-point hedonic scale)

The hedonic test was conducted following the method outlined by Meilgaard *et al.* (2007) to assess participants' acceptance of the health bar samples. Seventy untrained panellists, aged 10 to 16 years, were asked to evaluate two health bar formulations with the most optimal proximate composition based on prior analysis. A five-point picture hedonic scale, ranging from 1 (Extremely Dislike) to 5 (Extremely Like), was used for assessment. Referring to Stone, Bleibaum & Thomas (2021), a five-point picture hedonic scale was the most suitable scale to test the acceptability of food products among children and adolescents (5 to 16 years) due to its simplicity and directness. A minimum explanation was required to help the panellists understand the point of the test. All samples were standardised to approximately 3.0 g to minimise bias and presented on plates with unique three-digit random codes. These codes were not repeated, and their sequence was recorded in a master list, accessible only to the researcher.

2.2.2 Study design

The school selection criteria included being a boarding school (*Madrasah*), located near Gombak, and having a majority of B40 students. Two schools meeting these criteria were chosen (through purposive sampling based on school location and B40 demographic profile), and data collection involved interviewing teachers and administrators to recruit participants aged 10 to 16 years. Academic and health records were reviewed to analyse their background, academic performance, and health status, including allergies. Teachers and administrators were also interviewed to assess students' behaviour in the classroom before consuming the health bar. The sample size was calculated as Whyte & Williams (2015) suggested, suggesting 51 participants for this study. However, to boost confidence in the result, the sample size was adjusted to an 80% response rate, giving 70 participants while considering 80% power and 5% significance level. Finally, selected participants (54 male and 16 female) received health declarations and informed consent forms to confirm eligibility.

2.2.3 Measurements

All selected participants were assessed before the start of the study (pre-intervention) and every two weeks right after the healthy bar intervention (post-intervention) for two months. The questionnaires were prepared in Malay to help participants understand them better. The questionnaires used in this study were pre-existing, previously tested, and validated in earlier research. They asked about participants' socio-demographic backgrounds, including sex, age, ethnicity, and date of birth (Teo *et al.,* 2019). The collected information was gathered for further study at a later stage.

2.2.4 Health bar pilot food intervention study

The pilot intervention study on the health bar was conducted over eight weeks (approximately two months), with participants receiving one health bar each morning to assess improvements in cognitive function (Ferry *et al.,* 2013), and the data collection took place every two weeks. All participants were instructed to refrain from consuming supplements or '*sunnah* food' during the intervention period to minimise bias. As Pribis *et al.* (2012) noted, the human body typically requires two to three months to respond to a consistent dietary intake. The intervention was divided into two phases: pre-intervention (before the study) and post-intervention (during the study). Data collection assessed participants' health status, health-related quality of life, and cognitive performance following two months of health bar consumption (Teo *et al.,* 2019). This study aimed to investigate the potential changes between the pre-intervention and post-intervention of the health bar. Therefore, the biweekly data were analysed by comparing baseline measurements with the final results. Finally, statistical analysis was performed to evaluate the collected data.

2.2.5 Pre-intervention of health bar

A briefing session was held for all participants and teachers one day before the health bar intervention to explain the study's objectives and procedures. Participants received a form to track their health bar consumption over two weeks. They were

instructed to maintain their regular daily diet, consuming meals of similar composition and quantity to reduce individual variability (Al Mana & Robertson, 2018). To ensure dietary habits remained unchanged throughout the study, participants recorded 24-hour dietary recalls (food logs) for accuracy and completeness. The form was designed for daily, weekly, and monthly entries. Since participants were in a boarding school, their food intake was generally consistent. Any uncertainties were addressed immediately. Lastly, all participants underwent assessments for anthropometric measurements, health-related quality of life, and cognitive performance.

2.2.6 Anthropometric measurements

At first, participants' body weight and height were measured using a weighing scale and stadiometer and recorded to the nearest 0.1 kg and 0.1 cm, respectively. These measurements were used to compute Body Mass Index (BMI). The z-scores for weight-for-age (WAZ), height-for-age (HAZ), and BMI-for-age (BAZ) were determined using WHO AnthroPlus software (World Health Organisation, 2009) to assess the nutritional status of children by comparing the z-scores against the WHO Growth Reference 2007 tables (World Health Organisation, 2009).

2.2.7 Health-related quality of life

The Pediatric Quality of Life Inventory 4.0 (PedsQL 4.0) was utilised to evaluate the health-related quality of life (HRQoL) of the participants (Varni *et al.,* 2001). To ensure better alignment with the participants, this study used the validated Bahasa Melayu version of the PedsQL 4.0 (Ab. Rahman *et al.,* 2011), allowing participants to complete the inventory in Malay. This instrument consisted of 23 items divided into four subscales: My health and activities, My feelings, I can get along with others, and About school. Participants were instructed to recall any health-related issues experienced over the past month and rate each item on a 5-point Likert scale ranging from 0 (never) to 4 (almost always). Subsequently, scores were transformed onto a 0–100-point scale, with 0 representing the highest level of impairment and 100 indicating the absence of impairment.

2.2.8 Cognitive performance

All participants were assessed using Rey's Auditory-Verbal Learning Test (RAVLT) to evaluate their cognitive performance before the health bar intervention. The recruited participants listened to 15 words (List A) followed by immediate recall of the words five times. After that, an interference list of 15 words (List B) was provided to the participants for immediate recall. The participants were then asked to perform short (2 mins) delayed recall of the 15 words (List A). At the end of the test, each participant was provided a printed list of 50 words (15 words from List A, 15 from List B, and an additional 20 words) and was required to circle only the 15 words from List A. The score was analysed using a t-test and analysis of variance (ANOVA) (Whyte & Williams, 2015). The assessment results were recorded and compared with the post-intervention results later.

2.2.9 Post-intervention of health bar

The school teachers were thoroughly briefed on the procedures for administering the health bar. This ensured that all participants consistently consumed the health bar daily throughout the study. The teachers closely monitored the consumption and recorded each intake using a designated form, thereby maintaining adherence and ensuring the integrity of the intervention. According to Whyte & Williams (2015), the consumption frequency of 5-6 days for two weeks can be included for further assessments. Post-intervention of the health bar was conducted every two weeks by collecting the forms to assess the frequency of health bar consumption. Due to the consistent and careful monitoring by the teachers, all participants demonstrated full compliance with the health bar consumption protocol, thereby facilitating the reliable execution of subsequent assessments. After that, all participants were re-evaluated for health-related quality of life and cognitive performance. The results were compared against the pre-intervention of a health bar to assess the differences in both results.

2.3 Ethical approval

It was important to highlight that this research had applied and obtained ethical approval from the International Islamic University of Malaysia (IIUM) Research Ethics Committee (IREC) concerning IREC No: IREC 2022-197 expiring on 28th November 2023.

3. Results and discussion

3.1 Acceptance test (5-point hedonic scale)

The acceptance test involved evaluating the palatability of two health bar samples. A 5-point hedonic scale (visual rating) was applied due to the suitability with the age of the panellists (10 to 16 years). A simple graphic hedonic scale of 5-point was distributed to 70 untrained panellists with a range of 1 = Very bad, 2 = Bad, 3 = Maybe good or maybe bad, 4 = Good, and 5 = Very good (Stone *et al.,* 2008). All panellists were to rate two health bar formulations (Formulation 12 and Formulation 14) based on their acceptability of the samples. The results obtained were as shown in Table 1.

The data in Table 1 indicates that most panellists preferred the health bar from Formulation 14, with 74.3% rating it as "very good," compared to 21.4% for Formulation 12. Additionally, 71.4% rated Formulation 12 as "good," while 21.4% gave the same rating to Formulation 14. A small percentage (7.2% for Formulation 12 and 4.3% for Formulation 14) was neutral. Despite Formulation 12 receiving a high "good" rating, Formulation 14 was selected for mass production due to its highest acceptance rating. The higher content of date powder enhanced sweetness, while the reduced moringa powder minimised the aftertaste. Both formulations contained beneficial nutrients for cognitive function, but only Formulation 14 was chosen for the pilot food intervention study.

3.2 Anthropometric measurements information

Their physical and health education teacher recorded the weight and height of each participant. The related data was computed into the WHO AnthroPlus Software to generate the body mass index (BMI), weight-for-age z-score (WAZ), height-for-age z-score (HAZ), and BMI-for-age z-score (BAZ). The obtained z-scores were compared against the WHO Growth Reference 2007 for children and adolescents aged 5 to 19 years to assess the health and nutrient status of the participants (Teo *et al.,* 2019). Tables 2, 3, and 4 present the anthropometric data of the

Table 1. Acceptance test result of the health bar

Attribute	Health Bar Formulation	Frequency n = 70	Per cent (%)
Very bad	Formulation 12	-	-
	Formulation 14	-	-
Bad	Formulation 12	-	-
	Formulation 14	-	-
Maybe good or maybe bad	Formulation 12	5	7.2
	Formulation 14	3	4.3
Good	Formulation 12	50	71.4
	Formulation 14	15	21.4
Very good	Formulation 12	15	21.4
	Formulation 14	52	74.3

Table 2. Anthropometric data of participants aged 12 to 13 years

Parameter	n (%) / Mean ± SD		
	Male (n = 4)	**Female (n = 2)**	***p*-value**
Body weight (kg)	29.95 ± 6.98	37.00 ± 0.78	0.296
Height (cm)	154.00 ± 2.58	149.00 ± 1.41	0.615
BMI (kg/m²)	12.60 ± 3.12	15.70 ± 0.07	0.286
WAZ	NA	NA	-
HAZ	-0.28 ± 1.22	-1.06 ± 0.77	0.110
BAZ	-4.04 ± 2.34	-0.97 ± 0.81	0.432
Severe thinness	3 (75.00)	-	-
Thinness	-	-	-
Normal	1 (25.00)	2 (100.00)	-
Overweight	-	-	-
Obesity	-	-	-

Table 3. Anthropometric data of participants aged 14 to 15 years

Parameter	n (%) / Mean ± SD		
	Male (n = 36)	**Female (n = 14)**	***p*-value**
Body weight (kg)	58.26 ± 12.50	52.87 ± 8.53	0.398
Height (cm)	166.20 ± 5.59	152.30 ± 6.84	1.000
BMI (kg/m²)	21.02 ± 3.96	22.69 ± 2.46	0.416
WAZ	NA	NA	-
HAZ	0.39 ± 1.34	-1.08 ± 2.21	0.593
BAZ	0.79 ± 1.46	1.02 ± 1.54	0.075
Severe thinness	-	-	-
Thinness	4 (11.11)	-	-
Normal	16 (44.44)	7 (50.00)	-
Overweight	11 (30.56)	7 (50.00)	-
Obesity	5 (13.89)	-	-

Table 4. Anthropometric data of participants aged 16 to 17 years

Parameter	n (%) / Mean ± SD	
	Male (n = 14)	***p*-value**
Body weight (kg)	58.21 ± 12.96	1.000
Height (cm)	166.71 ± 4.94	1.000
BMI (kg/m²)	20.76 ± 3.86	1.000
WAZ	NA	-
HAZ	-0.80 ± 1.54	0.437
BAZ	0.17 ± 2.34	0.057

Severe thinness	-	-
Thinness	1 (7.14)	-
Normal	11 (78.58)	-
Overweight	1 (7.14)	-
Obesity	1 (7.14)	-

participants aged 12 to 13 years, 14 to 15 years, and 16 to 17 years, respectively.

Table 2 indicates no statistically significant differences between male and female participants aged 12 to 13 regarding body weight, height, or nutritional status as measured by HAZ and BAZ scores. However, a general pattern suggests that females tend to have slightly higher body weight and better nutritional status than males. Notably, while both genders fell within the expected growth ranges, the broader variability in male scores—particularly in BAZ—may point to greater disparities in nutritional conditions among boys. These findings suggest similar growth profiles, with minor gender-based differences in nutritional patterns worth further investigation. Compared to the WHO Growth Reference 2007, 5.56% of male participants were classified as severely thin despite having a normal height, similar to findings by Cheah *et al.* (2022), which linked severe thinness in urban children to financial hardship. Additionally, 1.85% of males and 12.50% of females had normal BAZ and HAZ scores.

Table 3 shows that the average body weight and height for male and female participants aged 14 to 15 were 58.26 ± 12.50 kg, 52.87 ± 8.53 kg, 166.20 ± 5.59 cm, and 152.30 ± 6.84 cm, respectively, with no significant difference ($p > 0.05$) between genders. Similarly, the HAZ and BAZ z-scores showed no significant variation. According to the WHO Growth Reference, over half of the male participants had normal BAZ scores, while 20.37% were overweight, 7.41% slightly thin, and 9.25% obese. Among females, 43.75% were classified as either usual or overweight. Research by Teo *et al.* (2019) suggests that adolescents in this age group can make balanced dietary choices, though some may struggle due to financial constraints (Suzana *et al.,* 2019).

The presented data in Table 4 were for male participants aged 16 to 17. Participants were selected randomly, but no female participants from this age group were included. The participants' mean body weight and height were 58.21 ± 12.96 kg and 166.71 ± 4.94 cm, respectively, with a 20.76 ± 3.86 kg/m2 BMI. The HAZ and BAZ mean z-scores were -0.80 ± 1.54 and 0.17 ± 2.34. Comparison with the WHO Growth Reference indicated that over half of the participants fell within the normal BAZ category. Meanwhile, another 5.56% were either slightly thin, overweight or obese.

These findings highlight the importance of continuously monitoring adolescents' growth and nutritional status across age groups. While most participants fell within the normal ranges, undernutrition (severe thinness among younger males) and overnutrition (overweight and obesity in mid-adolescents) suggest a dual burden of malnutrition. This pattern reflects broader public health concerns, particularly in urban or economically diverse settings, where dietary habits may vary widely due to food availability, education, and socioeconomic status. The data further reinforces the need for school-age and gender-sensitive nutritional interventions to promote healthy growth trajectories and reduce long-term health risks.

3.3 Result on health-related quality of life

The participants' health-related quality of life (HRQoL) was evaluated using Pediatric Quality of Life Inventory 4.0 (PedsQL 4.0). Health-Related Quality of Life (HRQoL) was a crucial healthcare metric. It comprehensively assessed the participants' physical, emotional, social, and functional well-being regarding their health status and medical interventions (Teo *et al.,* 2019). All participants were required to answer 23 items from four dimensions: physical, emotional, social, and school. They were requested to recall the health-related dimensions for the past month and rate the items on a scale of 0 to 4, and the scores were plotted on a different scale, with 0 = 100, 1 = 75, 2 = 50, 3 = 25, and 4 = 0. The results for HRQoL for male participants using one-way analysis of variance (ANOVA) were recorded before the intervention, after one month, and after two months of intervention and are presented in Table 5.

One-way ANOVA analysis of PedsQL 4.0 showed significant differences in physical well-being scores across intervention periods ($F = 24.181$, $p < .001$), suggesting the intervention positively impacted participants' overall health and functioning.

Similarly, the analysis also found significant differences in emotional well-being scores ($F = 14.460$, $p < .001$), indicating the intervention influenced mood, stress levels, and coping mechanisms. Similar results were reported by Cheah *et al.* (2022), highlighting improvements in emotional well-being.

Moreover, social well-being scores showed significant variations ($F = 34.409$, $p < .001$), reflecting changes in peer relationships and social interactions. As Allang *et al.* (2019) noted, strong peer support is essential for boarding school students' quality of life.

Notably, the most substantial improvement was observed in school-related functioning, indicating increased academic engagement and performance.

The effect size was calculated based on eta squared (η^2), which further supports the significant impact of the intervention. Physical well-being showed a large effect size ($\eta^2 = 0.317$), reflecting strong improvements in participants' physical health. Emotional well-being also demonstrated a significant effect ($\eta^2 = 0.218$), indicating meaningful changes in mood and coping. Social well-being exhibited an even more substantial effect ($\eta^2 = 0.398$), suggesting enhanced peer relationships and social support. Most notably, school-related functioning yielded a huge effect size ($\eta^2 = 0.920$), highlighting the substantial influence of the intervention on academic engagement and performance. These effect sizes affirm that the intervention meaningfully improved quality of life across multiple domains.

One-way ANOVA results showed significant improvements in physical well-being among female participants ($F = 45.500$, $p < .001$), indicating the intervention positively influenced their overall health and vitality.

Similarly, the analysis revealed significant enhancements in emotional well-being ($F = 19.891$, $p < .001$), suggesting the intervention strengthened coping mechanisms and emotional resilience over time.

Significant improvements were observed in social functioning ($F = 27.036$, $p < .001$), highlighting the intervention's role in fostering stronger relationships and social support. Qiao *et al.* (2021) noted that female adolescents often face greater peer interaction challenges, making social support crucial.

Although the impact was minor, school-related functioning also improved ($F = 6.980$, $p = .002$), indicating positive effects on academic performance and school engagement, though to a lesser degree than other dimensions.

Table 5. Pediatric Quality of Life Inventory (PedsQL 4.0) - result for male participants

Dimension	Intervention Period	Mean (%)	Std. Deviation	F	Sig.	η^2
Physical	Pre-intervention	93.25	0.167	24.181	<.001	0.317
	1-month intervention	95.00	0.151			
	2-month intervention	97.50	0.063			
	Total	95.00	0.153			
Emotional	Pre-intervention	89.00	0.313	14.460	<.001	0.218
	1-month intervention	91.25	0.226			
	2-month intervention	95.00	0.110			
	Total	91.75	0.251			
Social	Pre-intervention	83.00	0.335	34.409	<.001	0.398
	1-month intervention	86.00	0.215			
	2-month intervention	94.00	0.282			
	Total	87.75	0.335			
School	Pre-intervention	86.00	0.000	598.881	<.001	0.920
	1-month intervention	87.75	0.107			
	2-month intervention	95.00	0.000			
	Total	89.25	0.180			

Table 6. Pediatric Quality of Life Inventory (PedsQL 4.0) - result for female participants

Dimension	Intervention Period	Mean (%)	Std. Deviation	F	Sig.	η^2
Physical	Pre-intervention	92.50	0.062	45.500	<.001	0.765
	1-month intervention	95.00	0.062			
	2-month intervention	96.75	0.000			
	Total	94.75	0.087			
Emotional	Pre-intervention	83.75	0.339	19.891	<.001	0.587
	1-month intervention	88.75	0.089			
	2-month intervention	95.00	0.000			
	Total	89.25	0.272			
Social	Pre-intervention	88.75	0.089	27.036	<.001	0.659
	1-month intervention	91.50	0.120			
	2-month intervention	95.00	0.073			
	Total	91.75	0.140			
School	Pre-intervention	87.50	0.310	6.980	.002	0.333
	1-month	90.00	0.207			

	intervention					
	2-month intervention	94.75	0.089			
	Total	90.75	0.248			

Table 7. Rey's Auditory Verbal Learning Test (RAVLT) - Result for male participants

Total Recall	Intervention	Mean	Std. Deviation	F	Sig.
A1	PI	5.0	0.116	2.760	<.001
	I2	6.2	0.231		
	I4	7.3	0.116		
	I6	8.9	0.058		
	I8	9.2	0.288		
	Total	7.4	1.629		
A2	PI	7.2	0.116	1.001	.451
	I2	8.4	0.231		
	I4	38.7	50.518		
	I6	11.4	0.231		
	I8	12.5	0.173		
	Total	10.3	22.597		
A3	PI	9.9	0.173	2.814	<.001
	I2	10.6	0.116		
	I4	11.4	0.116		
	I6	13.3	0.289		
	I8	14.1	0.173		
	Total	11.8	1.660		
A4	PI	10.6	0.116	2.836	<.001
	I2	11.8	0.173		
	I4	12.5	0.173		
	I6	14.5	0.173		
	I8	15.2	0.404		
	Total	12.9	1.793		
A5	PI	10.9	0.173	1.173	<.001
	I2	11.9	0.116		
	I4	13.4	0.173		
	I6	14.9	0.404		
	I8	15.2	0.462		
	Total	13.2	1.756		
B1	PI	4.9	0.115	3.436	<.001
	I2	5.8	0.289		
	I4	7.2	0.231		
	I6	10.1	0.346		
	I8	10.6	0.115		
	Total	7.7	2.367		
A6	PI	10.0	0.173	1.600	<.001
	I2	10.7	0.404		
	I4	11.8	0.173		
	I6	13.6	0.115		
	I8	14.4	0.288		
	Total	12.1	1.724		
A7	PI	10.5	0.173	8.422	<.001
	I2	11.4	0.115		
	I4	12.6	0.115		
	I6	14.7	0.115		
	I8	15.0	0.000		

	Total	12.8	1.838		
Sum	PI	43.2	1.039	2.398	<.001
	I2	49.0	0.866		
	I4	54.2	0.692		
	I6	63.1	1.097		
	I8	66.3	1.501		
	Total	55.2	8.937		
Recognition	PI	10.4	0.231	4.713	<.001
	I2	11.6	0.115		
	I4	12.7	0.173		
	I6	14.8	0.173		
	I8	15.0	0.000		
	Total	12.9	1.852		

A1 – A5: Number of recalls for List A (5 times), B1: Number of recalls for List B (1 time), A6 – A7: Immediate recalls for List A (2 times), Recognition: Number of words from List A.

Table 8: Rey's Auditory Verbal Learning Test (RAVLT) - Results for female participants

Total Recall	Intervention	Mean	Std. Deviation	F	Sig.
A1	PI	5.8	0.289	1.497	<.001
	I2	6.4	0.231		
	I4	7.4	0.058		
	I6	9.0	0.000		
	I8	9.1	0.289		
	Total	7.6	1.394		
A2	PI	7.4	0.116	4.687	<.001
	I2	8.7	0.289		
	I4	9.7	0.000		
	I6	11.6	0.116		
	I8	12.5	0.173		
	Total	9.9	1.942		
A3	PI	10.1	0.173	3.321	<.001
	I2	10.8	0.173		
	I4	11.4	0.116		
	I6	13.4	0.173		
	I8	14.1	0.173		
	Total	11.9	1.597		
A4	PI	10.8	0.173	1.964	<.001
	I2	11.8	0.173		
	I4	12.5	0.173		
	I6	14.6	0.116		
	I8	15.2	0.404		
	Total	12.9	1.741		
A5	PI	11.0	0.058	1.518	<.001
	I2	11.9	0.116		
	I4	13.4	0.173		
	I6	15.1	0.289		
	I8	15.3	0.462		
	Total	13.3	1.740		
B1	PI	5.0	0.000	3.502	<.001
	I2	5.8	0.289		
	I4	7.2	0.231		
	I6	10.1	0.346		
	I8	10.6	0.115		
	Total	7.7	2.332		

A6	PI	10.2	0.289	1.096	<.001
	I2	10.9	0.462		
	I4	11.8	0.173		
	I6	13.6	0.115		
	I8	14.4	0.289		
	Total	12.2	1.647		

A1 – A5: Number of recalls for List A (5 times), B1: Number of recalls for List B (1 time), A6 – A7: Immediate recalls for List A (2 times), Recognition: Number of words from List A.

The favourable outcome observed in the health bar intervention's impact on Health-Related Quality of Life (HRQoL) was primarily attributed to the beneficial components presented in the health bar formula. This included the incorporation of dark chocolate compound, known to enhance mood according to research by Spencer *et al.* (2017), alongside date powder, recognised for its potential to bolster mental well-being based on findings by Moslemi *et al.* (2023). Over two months, the dietary intervention involving the consumption of health bars showed potential for improving individuals' overall quality of life.

Based on a sample size of 16 participants (df_between = 1, df_within = 14), the calculated effect sizes using eta squared (η^2) demonstrated the substantial impact of the health bar intervention. Physical well-being showed a huge effect size ($\eta^2 = 0.765$), indicating strong physical and vitality improvements. Emotional well-being ($\eta^2 = 0.587$) and social functioning ($\eta^2 = 0.659$) also reflected large effect sizes, suggesting significant enhancements in emotional resilience and social interactions. Meanwhile, school-related functioning showed a moderate to large effect size ($\eta^2 = 0.333$), indicating a noticeable, though comparatively more minor, improvement in academic engagement. These effect sizes highlight the meaningful influence of the intervention, even within a small sample.

3.4 Result on Rey's auditory verbal learning test

Before the intervention, rey's auditory verbal learning test (ravlt) was conducted every two weeks for two months. the results are tabulated in Table 7.

The Rey Auditory Verbal Learning Test (RAVLT) results for male participants following several weeks of intervention offer insights into the impact of the intervention on their memory performance. across different intervention periods, significant improvements were observed in total recall scores, as evidenced by notable increases in mean scores from the pre-intervention (p1) phase to subsequent intervention periods (12 (2-weeks of intervention), 14 (4-weeks of intervention), 16 (6-weeks of intervention), and 18 (8-weeks of intervention)) for each recall trial (a1 to a7). for instance, in trial a1, the mean recall score rose steadily from 5.0 in the pre-intervention phase to 9.2 in the final intervention phase (18). this pattern of improvement is consistent across all recall trials, demonstrating the effectiveness of the intervention in enhancing participants' ability to recall verbal information. these gains in verbal memory suggest improved capacity to retain instructions, remember learning material, and perform better in academic settings. enhanced memory supports everyday functioning, such as recalling schedules, organising tasks, and managing responsibilities more effectively.

Furthermore, recall scores across all trials significantly increased over the intervention periods, indicating a cumulative enhancement in memory performance. from a mean score of 43.2 in the pre-intervention phase, the total recall score rose to 66.3 in the final intervention phase (18), underscoring the overall efficacy of the intervention in improving memory function among male participants.

Additionally, in the recognition phase, significant improvements in recognition memory were observed across intervention periods. similar to the recall trials, there was a consistent upward trend in mean recognition scores from the pre-intervention phase to subsequent intervention phases (12, 14, 16, and 18). this suggested that the intervention enhanced participants' recall of information and improved their ability to recognise previously presented verbal stimuli. the result for ravlt for female participants was displayed in table 8.

The rey auditory verbal learning test (ravlt) results for female participants following several weeks of intervention shed light on the effects of the intervention on their memory performance. across various intervention periods, significant improvements were evident in total recall scores, underscoring the intervention's positive impact on memory function among female participants. notably, in each recall trial (a1 to a7), mean recall scores exhibited consistent increases from the pre-intervention (p1) phase to subsequent intervention phases (12, 14, 16, and 18). for example, in trial a1, the mean recall score rose steadily from 5.8 during the pre-intervention phase to 9.1 in the final intervention phase (18). this trend persisted across all recall trials, reflecting the effectiveness of the intervention in enhancing participants' ability to retrieve verbal information from memory.

Moreover, recall scores across all trials significantly increased over the intervention periods, indicating a cumulative improvement in memory performance among female participants. from a mean score of 45.1 in the pre-intervention phase, the total recall score escalated to 66.3 in the final intervention phase (18), highlighting the overall efficacy of the intervention in enhancing memory function. Furthermore, in the recognition phase, significant enhancements in recognition memory were observed across intervention periods. Similar to the recall trials, there was a consistent upward trajectory in mean recognition scores from the pre-intervention phase to subsequent intervention phases (I2, I4, I6, and I8). This indicated that the intervention enhanced participants' recall of previously presented verbal stimuli and improved their ability to recognise them when presented again.

The Rey Auditory Verbal Learning Test (RAVLT) results exhibited notable influence from the health bar intervention, attributed to its exceptional nutrient composition. The health bars, enriched with 1152 mg/kg magnesium, 0.80 mg/100g vitamin E, 8.91% DPPH inhibition, 6797.84 linoleic acid, and 3011.79 alpha-linolenic acid, showcased a robust combination of essential nutrients (Mohd Noor *et al.,* 2024). These nutrients were renowned for their potential cognitive benefits, including improved memory function and cognitive performance (Hashimoto & Hossain, 2011).

The observed gender differences in memory performance improvements may be attributed to several cognitive and neurobiological factors. Research suggests that females often exhibit stronger verbal memory and language-related processing, possibly due to differences in brain structure and hormonal influences such as oestrogen, which is known to affect hippocampal function—a key region for memory (Yasinta *et al.,* 2021). These biological advantages could partly explain why female participants demonstrated slightly higher baseline recall scores and more pronounced gains during the intervention (Spencer *et al.,* 2017). A similar study explained that social and behavioural factors, such as greater attentiveness, task engagement, or verbal rehearsal strategies commonly employed by female students, may have further contributed to their improved performance. These distinctions highlight the importance of considering gender-specific cognitive strengths when designing and evaluating memory-enhancing interventions.

Magnesium supports synaptic plasticity and neurotransmitter release, while vitamin E protects neurons from oxidative stress (Yasinta *et al.,* 2021). The health bars' antioxidant properties (8.91% DPPH inhibition) may further prevent neuronal damage and support cognitive health. Essential fatty acids also contribute to synaptic integrity and cognitive function.

Moreover, ingredients like date powder, moringa powder, sacha inchi oil, and pumpkin seeds provide antioxidants, polyphenols, flavonoids, omega-3s, zinc, and magnesium, all essential for neuroprotection and cognitive processing.

The intervention led to notable improvements in recall and recognition memory, highlighting the intervention's effectiveness in enhancing cognitive function and overall mental well-being among male participants. Female participants demonstrated parallel gains, further supporting the potential of the health bar intervention to enhance cognitive performance.

4. Conclusion

The study assessed health and cognitive performance improvements among children and adolescents through a combined survey and health bar intervention. Anthropometric data and cognitive function were evaluated across different age groups. The study analysed body weight, height, and BMI, identifying variations in nutritional status, including cases of malnutrition, obesity, and growth patterns, which highlighted the diverse nutritional challenges within the community.

Moreover, cognitive function was measured using PedsQL and RAVLT. The PedsQL results showed improvements in physical, emotional, social, and school-related well-being, particularly among males. The RAVLT indicated enhanced recall and recognition memory in both genders.

The intervention significantly improved health and cognitive performance, with notable benefits for both male and female participants. The study emphasised the role of socioeconomic and environmental factors in influencing these outcomes, highlighting the need for targeted interventions to address food insecurity.

Overall, the health bar intervention positively impacted health and cognitive performance in children and adolescents from the B40 community, demonstrating measurable improvement in nutritional programs in mitigating socioeconomic disparities in health and development. Otherwise, several adjustments are recommended for future research, including extending the intervention period for more robust results and considering combining multiple methods to collect data.

This study highlights the crucial link between nutrition and cognitive performance, particularly in children and adolescents, emphasising its impact on academic success. It underscores the importance of a holistic educational approach that integrates health promotion—such as nutrition education, access to healthy meals, and physical activity—into school settings. By doing so, educators and policymakers can better support students' physical, mental, and emotional well-being, ultimately enhancing learning outcomes. The findings also call for institutional and government-level policy changes prioritising student nutrition, particularly for low-income communities. These include increased funding for school meal programs, stricter nutrition standards, and collaborative strategies between the health and education sectors. Professional development for educators on nutrition and health can further strengthen their ability to foster supportive and healthy learning environments.

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