EFFECTS OF BRAIN-BREAKS EXERCISE VIDEO PROGRAM ON FUNDAMENTAL MOTOR SKILLS PERFORMANCE AMONG THE PRIMARY SCHOOL STUDENTS IN KAPIT, SARAWAK

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by

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LIST OF ABBREVIATIONS

ANOVA	Mixed factorial analysis of variance
APAS	Attitudes toward Physical Activity Scale
BPK	*Bahagian Pembangunan Kurikulum*
CAMSA	Canadian Agility and Movement Skill Assessment
CAPL-2	Canadian Assessment of Physical Literacy – Second Edition
CDC	Centres for Disease Control and Prevention
CI	confidence interval
FMS	fundamental motor skill
FMSQ	Fundamental Motor Skills Quotient
GCH	Global Community Health
GMDQ	gross motor development quotient
HALO	Healthy Active Living and Obesity Research Group
HPE	Health and Physical Education
IAT	Illinois Agility Test
ICC	Intra-Class Correlation Coefficients
IPH	Institute of Public Health
KPM	*Kementerian Pendidikan Malaysia*
KTK	*Körperkoordinationstest für Kinder*
MAB-C	Movement Assessment Battery for Children
NCD	non-communicable diseases
NHMS	National Health Morbidity Survey
PA	physical activity
PE	Physical Education
POC	Process Orient Checklist
RSS-1MD	Repeated Side step-1 meter distance
RSS-HHD	Repeated Side Step- Half of height
SDGs	Sustainable Developmental Goals
SEGAK	National Physical Fitness Standard Test
SPSS	Statistical Package for Social Science
TGMD	Test of Gross Motor Development
TGMD-2	Test of Gross Motor Development – Second Edition

TGMD-3	Test of Gross Motor Development – Third Edition
UN	United Nations
USM	Universiti Sains Malaysia

LIST OF APPENDICES

KESAN PROGRAM VIDEO SENAMAN BRAIN-BREAKS TERHADAP PRESTASI KEMAHIRAN MOTOR ASAS DALAM KALANGAN MURID SEKOLAH RENDAH DI KAPIT, SARAWAK

ABSTRAK

Penguasaan kemahiran motor asas dalam kalangan kanak-kanak adalah penting bagi kanak-kanak untuk melibatkan diri dalam aktiviti fizikal dan menjalani gaya hidup aktif yang akan memberi impak yang positif terhadap perkembangan fizikal, kognitif, dan sosial mereka. Walau bagaimanapun, terdapat bukti yang menunjukkan bahawa penguasaan kemahiran motor asas dalam kalangan kanak-kanak adalah rendah. Kajian ini melibatkan dua kajian yang saling berhubung kait dan dibahagikan kepada 2 fasa: (1) Kajian rentas (2) Kajian intervensi. Instrumen *Canadian Agility and Movement Skill Assessement* (CAMSA) digunakan bagi pengumpulan data kedua-dua fasa kajian. Fasa 1 kajian adalah untuk mengenal pasti skor ujian kemahiran motor asas kanak-kanak Sarawak berdasarkan jantina dan mengenal pasti persentil jumlah skor kemahiran motor asas kanak-kanak Sarawak berdasarkan jantina dan umur. Data telah dianalisis menggunakan statistik deskriptif (min, sisihan piawai, persentil, analisis silang). 385 murid dipilih secara rawak daripada 4 sekolah rendah yang dijemput dari 3 bahagian di Sarawak (Kuching, Kota Samarahan, Kapit). Lelaki mendapat skor yang lebih tinggi daripada perempuan bagi semua pembolehubah; masa yang diambil (lelaki, 28.65 ± 6.29; perempuan, 28.09 ± 5.15), skor masa (lelaki, 3.04 ± 2.20; perempuan, 2.93 ± 1.82), skor kemahiran (lelaki, 8.39 ± 2.51; perempuan, 7.84 ± 2.62), jumlah skor CAMSA (lelaki, 11.42 ± 3.91; perempuan, 10.77 ± 3.62) dan interpretasi (lelaki, 1.09 ± .30; perempuan, 1.06 ± .23). Di samping itu, persentil jumlah skor kemahiran motor asas kanak-kanak Sarawak

adalah lebih rendah berbanding kanak-kanak Kanada. Fasa 2 kajian bertujuan untuk menguji kesan program video senaman *Brain-Breaks* terhadap prestasi kemahiran motor asas dalam kalangan murid sekolah rendah di Kapit, Sarawak. 104 murid daripada 2 sekolah rendah yang dijemput di Kapit menyertai kajian ini. Berikutan ujian pra, 2 buah sekolah tersebut telah dibahagikan secara rawak kepada kumpulan intervensi (n = 53) dan kumpulan kawalan (n = 51). Kumpulan intervensi menerima dua sesi *Brain-Breaks* selama 30 minit seminggu dalam tempoh 7 minggu, manakala kumpulan kawalan meneruskan kelas Pendidikan Jasmani (PJ) seperti biasa dalam tempoh 7 minggu. Sebuah ujian pasca telah dijalankan selepas intervensi selama 7 minggu. Analisa varians (ANOVA) campuran digunakan untuk menganalisis kesan "*Brain-Breaks*" terhadap pembolehubah kajian. ANOVA campuran menunjukkan perubahan yang signifikan (kesan masa) terhadap skor kemahiran, $F(1,102) = 73.85$, nilai $p = < .001$; jumlah skor CAMSA, $F(1, 102) = 52.94$, nilai $p = < .001$; dan interpretasi, $F(1, 102) = 15.57$, nilai $p = < .001$. Terdapat perbezaan yang signifikan antara kumpulan dalam skor kemahiran, $F(1, 102) = 35.21$, nilai $p = < .001$; dan jumlah skor CAMSA, $F(1, 102) = 5.81$, nilai $p = .018$. Kesan interaksi yang signifikan telah ditemui bagi skor kemahiran, $F(1, 102) = 17.07$, nilai $p = < .001$. Kesimpulannya, skor kemahiran dan jumlah skor CAMSA dalam kalangan murid sekolah rendah meningkat dengan signifikan berikutan intervensi *Brain-Breaks*. Program dan strategi intervensi perubahan tingkah laku adalah penting dalam memperoleh kemahiran motor asas dalam kalangan pelajar sekolah rendah yang menjadi teras kepada penyertaan sukan dan aktiviti fizikal.

EFFECTS OF BRAIN-BREAKS EXERCISE VIDEO PROGRAM ON FUNDAMENTAL MOTOR SKILLS PERFORMANCE AMONG THE PRIMARY SCHOOL STUDENTS IN KAPIT, SARAWAK

ABSTRACT

Proficiency in Fundamental Motor Skills (FMS) among children is important for children to engage in physical activity (PA) and live an active lifestyle which will bring positive implications to their physical, cognitive, and social development. However, there is evidence that indicates low proficiency in FMS among children. The study involved two interrelated studies and was divided into 2 phases: (1) Cross-sectional study (2) Interventional study. Data for both study phases were collected using the Canadian Agility and Movement Skill Assessment (CAMSA) instrument. Phase 1 of the study aimed to identify the Sarawakian children's FMS test scores based on gender and to identify the percentiles of total FMS score among Sarawakian children based on gender and age. Data were analysed using the descriptive statistics (mean, standard deviation, percentiles, crosstabs). 385 students were randomly selected from 4 invited primary schools from 3 divisions in Sarawak (Kuching, Kota Samarahan, Kapit). Males scored higher than females in all variables; completion time (males, 28.65 ± 6.29; females, 28.09 ± 5.15), time score (males, 3.04 ± 2.20; females, 2.93 ± 1.82), skill score (males, 8.39 ± 2.51; females, 7.84 ± 2.62), total CAMSA score (males, 11.42 ± 3.91; females, 10.77 ± 3.62), and interpretation (males, 1.09 ± .30; females, 1.06 ± .23). In addition, the the Sarawakian children's total FMS score percentiles were lower as compared to the Canadian children. Phase 2 aimed to examine the effects of Brain-Breaks exercise video program in FMS performance among the primary school students in Kapit, Sarawak. 104 students from 2 invited

primary schools in Kapit, Sarawak participated in the study. Following the pre-test, the schools were randomly assigned to an intervention group (n = 53) and a control group (n = 51). The intervention group received two-30 minutes Brain-Breaks sessions per week for 7 weeks and the control group continued with their regular Physical Education (PE) class for 7 weeks. A post-test was conducted following the 7-week intervention. Mixed factorial analysis of variance (ANOVA) was used to examine the effects of Brain-Breaks on the study variables. A mixed ANOVA showed significant changes (time effect) on skill score, $F(1,102) = 73.85$, p-value = < .001; total CAMSA score, $F(1, 102) = 52.94$, p-value = < .001; and interpretation, $F(1, 102) = 15.57$, p-value = < .001. There were also significant differences between groups on skill score, $F(1, 102) = 35.21$, p-value = < .001; and total CAMSA score, $F(1, 102) = 5.81$, p-value = .018. A significant interaction effect was found for skill score, $F(1, 102) = 17.07$, p-value = < .001. In conclusion, the skill score and total CAMSA score among primary school students significantly improved following the Brain-Breaks intervention. Behavioural change intervention programs and strategies are essential in the acquiring of fundamental motor skills among the primary school students which are central to sports participation and physical activities.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

The prevalence of overweight and obesity continues to be a severe threat to public health worldwide, especially among school children. Several studies (Alagappan et al., 2019; Lai et al., 2022; Lasarte-Velillas et al., 2023; Zhang et al., 2018) in recent years have reported the prevalence of overweight and obesity among school children. Specifically, in China, it was reported that the prevalence of overweight and obesity among Chinese primary school students from 2014 to 2017 was 15.2% and 11.7% respectively (Zhang et al. 2018). Additionally, the prevalence of overweight and obesity among Malaysian secondary school children had been rising whereby Alagappan et al. (2019) reported that 27.5 % of Malaysia secondary school children were overweight and obese (16% overweight and 11.5% obese), whereas Lai et al. (2022) reported that the prevalence of overweight and obesity among Malaysian secondary school children was 31.9% (17.0% overweight and 14.9% obese). Further, in Aragón, 31.1% of children between the ages of 2 and 14 years were classified as overweight and obese (Lasarte-Velillas et al., 2023).

Several studies (Dobbie et al., 2022; Wiklund, 2016) had reported that physical activity (PA) is an efficient method to combat overweight and obesity. However, children and adolescents' lack participation in PA continues to be a challenge to combating this problem. Data from the National Health Morbidity Survey (NHMS) provided by the Institute of Public Health (IPH, 2017) revealed that the prevalence of physically active Malaysian secondary school students was 19.8% whereas 39% of the students were not physically active (IPH, 2019). In this regard, a surge in the prevalence of overweight and obesity among adults will be inevitable as exercise

habits tend to get carried over into adulthood (Tomaczkowski & Klonowska, 2020). The lack of participation in PA by children and adolescents continues to worsen as the world is now in a global crisis due to the COVID-19 pandemic. A review paper by Neville et al. (2022) reported that during the COVID-19 pandemic, children's and adolescents' PA levels had decreased significantly. In addition, a study conducted by Dunton et al. (2020) found that between the pre-COVID-19 and early-COVID-19 period, PA among children showed a decrease while their sedentary behaviour showed an increase as perceived by their parents. Thus, this will lead to an increase in non-communicable diseases (NCD) and other health-related diseases as children move less and less to achieve an adequate amount of daily PA.

In addition to the health-related physical fitness components (i.e., cardiovascular and muscular endurance, muscle strength, flexibility, and body composition), PA also included motor skills. Children's engagement in PA can increase their participation in sports and games as the motor skills involved are trained and taught properly. Hence, they will be able to perform better and sustain their participation in PA. Moreover, children with higher fundamental motor skills (FMS) competency levels will be able to engage in a diverse form of physical activities, games, and sports (Cohen et al., 2014) whereby they will be motivated to engage in higher levels of PA and vice versa for children with lower FMS competency (Stodden & Goodway, 2007).

At present, numerous tools have been developed to assess FMS performance and among them is the Canadian Agility and Movement Skill Assessment (CAMSA) (Healthy Active Living and Obesity Research Group – HALO, 2017). The CAMSA is an instrument developed in Canada to evaluate and assess the FMS of children aged between 8 and 12 years old. It requires children to complete seven skills; two-foot

jumping, sliding, catching, throwing, skipping, one-foot hopping, and kicking continuously in which their time to complete all seven skills and the execution of 14 skills criteria will be recorded by the test administrators. Apart from Canadian (Longmuir et al. 2017), CAMSA has also been validated in Australia (Lander et al., 2017a), China (Cao et al., 2020; Chang et al., 2021) and Spain (Menescardi et al., 2022) in assessing the FMS performance in children. These studies indicate great evidence supporting the validity and reliability of CAMSA among children aged 8 to 12 years old.

According to Stodden et al. (2008), children's PA is determined by their motor skills as well as their health-related fitness and self-perceived motor skill competence. Therefore, there is a need to assess and evaluate children's FMS performance as the FMS is crucial for children to be physically competent and participate in various forms of PA. In this regard, there is strong evidence suggesting a positive relationship between children's FMS performance and PA in a systematic review by Lubans et al. (2010). Thus, to sustain children's engagement in PA, they must be proficient in FMS parallel with their age. By examining children's FMS performance, early FMS intervention strategies can be implemented to improve their motor skills and sustain their engagement in PA.

An FMS intervention using the aid of technology should be promoted to enhance children's FMS levels. In this regard, Brain-Breaks has been used globally as a video-based PA intervention (Balasekaran et al., 2021; Mok et al., 2020). Brain-Breaks is a short video on physical exercise that incorporates motor and fitness skills as well as cultural awareness which is accessible via the web (Kuan et al., 2019) and has been proven to be successful in inducing PA among elementary school students (Bobe et al., 2014). It aims to enhance children's motor skills, fitness, and coordination

(Chin et al., 2012; Susiolo et al., 2021) by having the children copy the movements shown in the video. Past studies have found that Brain-Breaks had a positive impact on students' motivation and attitudes toward PA (Balasekaran et al., 2021; Hajar et al. 2019; Mok et al., 2020; Popeska et al., 2018; Rizal et al., 2019; van Stryp et al., 2021). Nevertheless, the effect of Brain-Breaks videos on FMS performance is still unknown.

Further, the implementation of FMS assessment, as well as FMS intervention in Sarawak remains uncertain although several studies have proven the importance of FMS in promoting children's engagement in PA. In addition, there is a lack of information on these topics not only in the Sarawakian context but in the Malaysian context generally. Therefore, the purpose of this study is to identify the Sarawakian children's FMS test scores (based on CAMSA) as well as to examine the effects of the Brain-Breaks exercise video program on the FMS performance among the primary school students in Kapit, Sarawak. This study was divided into 2 phases which are outlined in Table 1.1.

Table 1.1 Research Study Map

Phase	**Overview**
Phase 1	A cross-sectional study to identify the Sarawakian children's FMS test scores and percentiles of total FMS score (based on CAMSA)
Phase 2	An experimental study to examine the effects of the Brain-Breaks exercise video program on the FMS performance among primary school students in Kapit, Sarawak

1.2 Problem statement

The FMS which formed the fundamental building blocks of PA is comprised of manipulative skills, locomotor skills, and stability skills (Gallahue et al., 2012). A high level of FMS performance in children is important for children to engage in PA and live an active lifestyle. This is because children who engage in PA will develop better physically, cognitively, and socially (Tomaczkowski & Klonowska, 2020). For instance, PA will improve general health (Crumbley et al., 2019), lower the risk of chronic diseases (Michel et al., 2022), improve concentration and attention (Buchele Harris et al., 2018), lessen depressive symptoms, behavioural and emotional difficulties (Booth et al., 2023), and foster a sense of confidence and trustworthiness (Di Bartolomeo & Papa, 2019).

However, there were evidence that indicated poor performance in FMS among children (Jakiwa & Suppiah, 2020; Kelly et al., 2019; Lawson et al., 2021). In Ireland, less than 36% of percentage mastery was found among primary school students for all 15 of the FMS (i.e., skip, run, horizontal jump, gallop, slide, hop, two-hand strike of a stationary ball, one-hand stationary dribble, one-hand forehand strike of a self-bounced ball, two-hand catch, overhand throw, kick a stationary ball, underhand throw, vertical jump, and single leg stance) that were assessed (lowest = gallop, 1.4%; highest = slide, 35.7%) (Kelly et al., 2019). Similarly, in England, among 216 primary school students aged 7 to 10 years, less than 40% of the students demonstrated proficiency in any of the skills (i.e., run, jump, underarm and overarm throw, stability, catch, skip, and hop), with 27% of the students not proficient in all eight skills tested (Lawson et al., 2021). Further, in a study conducted by Jakiwa and Suppiah (2020), the motor performance level of children aged 8 and 9 years old in Malaysia was at a low level compared to their chronological age as they exhibited 5- and 6-year-old

motor performance levels for locomotor skills as well as 6- and 7-years old motor performance level for object control skills. However, to date, there is a lack of information and studies on FMS performance among children in Malaysia.

If this problem persists, children will engage less in PA as their poor performance in FMS will hinder them from participating in varieties of PA. According to Stodden et al. (2008), motor skill competence and low levels of PA during childhood may relate to each other. Children who have a low level of motor competency may be less willing to engage in PA thus decreasing their participation in PA (Malina et al., 2004). In other words, their deficiency in FMS simultaneously decreases their participation in PA which will lead to an increase in the overweight and obesity rate. Children who are overweight and obese often have a poor-self-perception, which has negative effects on their well-being. In particular, Latzer and Stein (2013) found that obese children had poor self-perception. In addition, a review by Hill (2017) revealed that obese children had lower self-worth than their normal-weight peers. Furthermore, it was reported in a review by Wang et al. (2019) that compared to non-overweight and obese children, overweight and obese children exhibited higher depression and anxiety symptoms.

As PA, exercise, and sports aim to promote PA and improve health, and psychosocial development (Holt et al., 2017), the decline in PA has impacted the students' overall physical and mental health (Jeong & So, 2020). In addition, the FMS, which is the key focus and element of primary physical education curricula is often oversight and generally poor (Zimmer et al. 2016) whereby early interventions are needed to address these difficulties as FMS are the foundation skills which lead to specialised movement sequences in an organised and non-organised PA (Clark & Metcalfe, 2002; Morgan et al., 2013). Poor performance in FMS has been found in

numerous countries not mastering these movement skills as the students progress from primary to secondary school (Bardid et al., 2016; Foweather, 2010; Hardy et al., 2013). Therefore, it is crucial to examine children's FMS performance as their engagement in PA is positively associated with their overall development. A physically competent child who engages in a moderate and vigorous PA will lead a healthy physical, mental, and social life. In addition, it was reported that there is a lack of FMS assessment. Specifically, the assessment of FMS is lacking in the Chinese National Physical Fitness Standard (revised version, 2014) in China (Ministry of Education of the People's Republic of China, 2014).

There are limited studies that have examined children's FMS in Asian countries (Chan et al., 2018), particularly in Malaysia. There are bound to be differences in FMS performance between different countries due to cultural and regional differences (Cao et al. 2020; Luz et al., 2019). Furthermore, a better understanding of FMS in children could extend the current review on FMS which could bring better and more effective interventions in line with PA that could increase the PA levels among children.

1.3 Rationale of the study

The rationale of this study is to assess Malaysian children's fundamental movement skills (FMS) which represent the foundation of complex skills that children need to acquire and learn for them to participate in games, physical activities, and sports. Currently, there are no formal assessments of FMS in school children in Malaysia which could result in delayed and limited development of motor skills and a decline in their health. The formal assessment of the FMS will be able to supplement the National Physical Fitness Standard Test (SEGAK) which is related to health-

related fitness. Furthermore, the intervention of utilising Brain-breaks videos on FMS would help foster the children's motor skills, fitness and coordination in a fun and creative way which can increase their skills performance and health in the long run.

1.4 Research questions

1. What are the Sarawakian children's FMS test scores (based on CAMSA) based on gender?
2. What are the percentiles of the total FMS score (based on CAMSA) among Sarawakian children based on gender and age?
3. What are the effects of the Brain-Breaks exercise video program on the FMS performance among primary school students in Kapit, Sarawak?

1.5 Research hypothesis

1. There is a significant change (time effect) in the FMS performance after the Brain-Breaks exercise video program among primary school students in Kapit, Sarawak.

2. There is a significant difference between the intervention and control groups (group effect) in the FMS performance after the Brain-Breaks exercise video program among primary school students in Kapit, Sarawak.

3. There is a significant interaction effect (time*group) of the Brain-Breaks exercise video program on the FMS performance between the interaction and control groups among primary school students in Kapit, Sarawak.

1.6 Research aim and objectives

1.6.1 General objectives

This study aimed to identify the Sarawakian children's FMS test scores and the percentiles of total FMS score (based on CAMSA) and examine the effects of the Brain-Breaks exercise video program on the FMS performance among primary school students in Kapit, Sarawak.

1.6.2 Specific objectives

1. To identify the Sarawakian children's FMS test scores (based on CAMSA) based on gender.
2. To identify the percentiles of the total FMS score (based on CAMSA) among Sarawakian children based on gender and age.
3. To examine the change of time effect, group effect, and interaction effect (time*group) in the FMS performance after the Brain-Breaks exercise video program among primary school students in Kapit, Sarawak.

1.7 Significance of the study

With the increase in the level of physical inactivity among children who do not meet the recommended PA level, the understanding of the assessment of Malaysian children's FMS is needed besides SEGAK which was implemented in 2008 to assess the student's level of health fitness. Therefore, there is a need for SEGAK to be integrated with an assessment of FMS through the CAMSA to make it more comprehensive and stay abreast with Physical Education (PE) and sports developments, advancement, and practices in PE knowledge. In addition, the assessment of FMS on Sarawakian students would enlighten the Ministry of Education, sports institutions, and organisations with evidence of their level of FMS

that can further the proficiency of motor skills and PA levels in PE. Moreover, the study would provide an influential role in the engagement of FMS interventions to improve the students' FMS performance, PA and sports across primary education (Babic et al., 2014).

1.8 Operational definitions

1.8.1 Fundamental motor skills (FMS)

Gallahue et al. (2012) defined the FMS as the fundamental building blocks of PA comprised of 3 skills subsets which are object control skills, locomotor skills, and stability skills. In this study, two subsets of FMS skills, locomotor skills and manipulative skills were included and tested among the participants. The locomotor skills included two-foot jumping, sliding, skipping, and one-foot hopping. Whereas the manipulative skills included catching, throwing, and kicking.

1.8.2 Brain-Breaks

In this study context, the Brain-Breaks video is a 5-minute video which focused on the seven CAMSA skills, namely, two-foot jumping, sliding, catching, throwing, skipping, one-foot hopping, and kicking.

1.8.3 Canadian Agility and Movement Skill Assessment (CAMSA)

CAMSA is a product and process assessment developed by HALO (2017) to measure the FMS performance among children aged 8 to 12 years. CAMSA requires children to complete seven skills, namely, two-foot jumping, sliding, catching, throwing, skipping, one-foot hopping, and kicking in succession. In this study, primary school students aged 10 to 11 years old participated and completed the CAMSA.

1.8.4 Primary school students

In Malaysia, primary school students refer to students aged 7 to 12 years old. In this study context, primary school students refer to students aged 10 to 11 years old.

1.8.5 Completion time

Completion time is the time participants took to complete all seven CAMSA skills (two-foot jumping, sliding, catching, throwing, skipping, one-foot hopping, and kicking) in a trial. The completion time was recorded by the first test administrators whereby the timing started when the first test administrators shouted 'Go' and stopped when the participants' foot made contact with the ball to kick the ball between two cones (See Figure 3.6).

1.8.6 Time score

The time score is a numerical value ranging from 1 to 14. It reflected the completion time whereby faster completion times are assigned a higher value and vice versa. Therefore, 1 is the lowest time score while 14 is the highest time score a participant can achieve.

1.8.7 Skill score

Skill score (range 0 to 14) is the total number of skills criteria that were correctly performed based on 14 skills criteria (See Table 3.1). Each correctly performed criteria skill was awarded 1 point while incorrectly performed criteria skill was awarded 0 points. Each CAMSA skill had different ranges of points; two-foot jumping (range 0 to 2), sliding (range 0 to 3), catching (range 0 to 1), throwing (range 0 to 2), skipping (range 0 to 2), one-foot hopping (range 0 to 2), and kicking (range 0 to 2).

1.8.8 Total CAMSA score

The total CAMSA score is a summed score generated from time and skill scores. The range of the total CAMSA score is from 1 to 28 whereby 1 is the lowest score while 28 is the highest score a participant can achieve. In this study, the total CAMSA score also referred to the total FMS score.

1.8.9 Interpretation

Interpretation is used to interpret the participants' FMS performance based on the total CAMSA score. It is divided into 4 categories (i.e., Beginning, Progressing, Achieving, and Excelling). "Beginning" indicated the lowest level of FMS performance exhibited by the participants while "Excelling" indicated the highest level of FMS performance exhibited by the participants.

1.8.10 CAMSA skill criteria

Each CAMSA skill (two-foot jumping, sliding, catching, throwing, skipping, one-foot hopping, and kicking) has 2 criteria except for "Catching", which has only 1 criterion (e.g., Catches ball – no dropping or trapping) and "Sliding", which has 3 criteria (e.g., Body and feet are aligned sideways when sliding in one direction, body and feet are aligned sideways when sliding in opposite direction, touch cone with low centre of gravity and athletic position). In this study context, each skill criterion is given a numerical value in addition to the skills name to differentiate the skill criteria. For example, the two-foot jumping skill is named "Two-foot Jumping 1" and "Two-foot Jumping 2" (See Table 3.1).

CHAPTER 2

LITERATURE REVIEW

2.1 Fundamental Motor Skills

Fundamental motor skills, or FMS, are regarded as the foundation for many specialised sports skills. As previously mentioned, the FMS is divided into three main categories, namely, manipulative skills, locomotor skills, and stability skills (Gallahue et al., 2012). The movement from one place to another is known as locomotor skills which involve running, jumping, hopping, sliding, galloping, and skipping skills (Lubans et al., 2010). The use of a body part (e.g., hand) or object (e.g., bat) to send or receive objects (e.g., ball) is known as manipulative skills, namely, catching, throwing, kicking, striking, and dribbling. Stability skills mainly involve balancing or postural control without moving from one place to another which includes dodging, twisting, turning, and bending (Lubans et al., 2010). As a foundation for movements in sports, a combination of two or all three FMS categories were required in sports. For example, all the FMS categories; locomotor skills (running, jumping), manipulative skills (catching, throwing, dribbling), and stability skills (dodging, turning, twisting, balance) were required when playing basketball (Gallahue & Ozmun, 2006). According to O'Keeffe et al. (2007), children have the potential to master the FMS by the age of six with proper guidance and practice. Nonetheless, evidence from studies worldwide has shown poor performance in FMS by children (Jakiwa & Suppiah, 2020; Kelly et al., 2019; Lawson et al., 2021). A variety of assessment tools have been designed and developed worldwide in recent decades to measure FMS performance in children.

2.1.1 Fundamental Motor Skills Assessment Tool

FMS assessment tools that have been developed worldwide generally measure either process or product-oriented assessment. The process-oriented assessment evaluates the quality of the technique when performing the skill (e.g., 'weight transfer and body rotation') (Logan et al., 2017) which includes the Test of Gross Motor Development (TGMD – Ulrich, 1985), Test of Gross Motor Development – Second Edition (TGMD-2 – Ulrich, 2000), Test of Gross Motor Development – Third Edition (TGMD-3 – Ulrich, 2019), and Get Skill Get Active (New South Wales Department of Education and Training, 2000). The product-oriented assessment includes the Movement Assessment Battery for Children (MAB-C) (Henderson & Sugden, 1992), the MAB-C – Second Edition (Henderson et al., 2007), and *Körperkoordinationstest für Kinder* (KTK – Kiphard & Schilling, 1974; Kiphard & Schilling, 2007) which assess the outcome of the skill performed in terms of time, distance, or accuracy (e.g., 'ball hits the target') (Logan et al., 2017). However, several FMS assessment tools measure both the process and product-oriented assessment. These include the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978) and the CAMSA (HALO, 2017). For this study, CAMSA was used to evaluate the FMS performance among primary school students in Sarawak.

2.1.1(a) Canadian Agility and Movement Skill Assessment (CAMSA)

Canadian Agility and Movement Skill Assessment or CAMSA is a valid and reliable process and product-oriented FMS assessment tool that was developed by HALO (2017) as part of the Canadian Assessment of Physical Literacy – Second Edition (CAPL-2). The purpose of CAMSA is to measure the FMS performance of children aged between 8 and 12 years. Originally developed in Canada, CAMSA provides normative data based on the Canadian children population. CAMSA is

comprised of seven FMS skills which can be divided into two FMS categories which are locomotor skills and manipulative skills. The locomotor skills include two-foot jumping, sliding, skipping, and one-foot hopping while the manipulative skills include catching, throwing, and kicking. All the seven skills have 2 criteria except for "Catching", which has only 1 criterion (e.g., Catches ball – no dropping or trapping) and "Sliding", which has 3 criteria (e.g., Body and feet are aligned sideways when sliding in one direction, body and feet are aligned sideways when sliding in opposite direction, touch cone with low centre of gravity and athletic position).

The norm for CAMSA was established based on data collected on more than 10,000 Canadian children (HALO, 2017). CAMSA, as reported by several studies took less than 30 seconds to administer per trial. Specifically, Lander et al. (2017a) revealed a mean time of 15 seconds completion time per trial while Cao et al. (2020) reported a mean time of 19.3 ± 5.3 (s). The scoring for CAMSA is marked objectively, where 1 mark is awarded if the skill is performed correctly, and 0 marks are awarded if the skill is performed incorrectly. In addition, the CAMSA scoring is divided into two components which are the time score and the skill score. The sum of the time score and the skill score from a timed/scored trial are summed to attain a total CAMSA score. The total CAMSA score is then interpreted into four categories, namely "Beginning", "Progressing", "Achieving", and "Excelling".

As previously mentioned, the CAMSA was originally developed and validated in Canada (Longmuir et al., 2017). Following the development of CAMSA, several studies on CAMSA have been conducted in various countries and have reported its reliability (Chang et al., 2021; Lander et al., 2017a; Menescardi et al., 2022) and validity (Cao et al., 2020; Lander et al., 2017a; Menescardi et al., 2022). The reliability and validity of the CAMSA were first reported by Longmuir et al. (2017) which

included test-retest, inter-rater, and intra-rater. The CAMSA's reliability had been demonstrated to be substantial-to-excellent (Chang et al., 2021; Lander et al., 2017a; Longmuir et al., 2017; Menescardi et al., 2022), demonstrating its capacity to assess FMS performance in children. The reliability and validity of the CAMSA are outlined in Table 2.1.

Table 2.1 Reliability and validity of the CAMSA

Author	Participants *N*; age	Country	Reliability			Validity
			Inter-rater	Intra-rater	Test-retest	Concurrent
Longmuir et al. (2017)	995 children aged 8-12 years	Canada	(i) Completion time (ICC = 0.99) (ii) Skill score (ICC - 0.69)	(i) Completion time (ICC = 0.99) (ii) Skill score (ICC - 0.52)	(i) Completion time (2 – 4 days; ICC = 0.84) (8 – 14 days; ICC = 0.82) (ii) Skill score (2 – 4 days; ICC = 0.46) (8 – 14 days; ICC = 0.74)	Not Tested
Lander et al. (2017a)	34 Year 7 females (mean age 12.6 years)	Australia	Not Tested	Not Tested	(i) Overall CAMSA score (ICC = 0.91) (ii) Time score (ICC = 0.80) (iii) Skill score (ICC = 0.85)	Victorian FMS Assessment (r = 0.68)
Cao et al. (2020)	149 males (mean age 9.0 ± 0.8 years)	China	Not Tested	Not Tested	Not Tested	CAMSA timing components (completion time and time score) IAT, r = 0.77; RSS-1MD, r = −0.76; RSS-HHD, r = −0.77

Table 2.1 Continued

Author	Participants *N*; age	Country	Reliability			Validity
			Inter-rater	Intra-rater	Inter-rater	Intra-rater
Chang et al. (2021)	1094 children aged 9-12 years	China	Not Tested	Not Tested	(ICC = 0.979 – 0.987)	Not Tested
Menescardi et al. (2022)	749 children aged 8-14 years	Spain	ICC = 0.83 – 1.00	ICC = 0.99 – 1.00	ICC = 0.70 – 0.83	KTK (r = 0.45)

*Intra-Class Correlation Coefficients (ICC), Illinois Agility Test (IAT), Repeated Sidestep-1 meter distance (RSS-1MD), Repeated Side Step-Half of height (RSS-HHD), *Körperkoordinationstest für Kinder* (KTK)

Longmuir et al. (2017) examined the feasibility, objectivity, and reliability of the CAMSA. The analysis revealed that the CAMSA was feasible for all 995 participants in the study. The inter-rater objectivity was excellent and substantial for completion time (Intra-Class Correlation Coefficients, ICC = 0.99) and skill score (ICC = 0.69) respectively. In addition, intra-rater objectivity for completion time also showed an excellent result (ICC = 0.99) while the skill score was moderate (ICC = 0.52). In terms of reliability, the results revealed excellent reliability for completion time over a short (2–4 days; ICC = 0.84) and long interval (8–14 days; ICC = 0.82). As for the skill score, the reliability was moderate (ICC = 0.46) over a short interval and substantial (ICC = 0.74) over a long interval. The study also investigated the difference between indoor and outdoor (95% confidence interval (CI) of difference: –0.7 to 0.6; $p = 0.91$) as well as with or without footwear (95% CI of difference: –2.5 to 1.9; $p = 0.77$) for the total CAMSA score which recorded no difference for all variables. It was also revealed that a higher total CAMSA score was reported for older age ($p < 0.001$, $\eta 2 = 0.15$) and male gender ($p < 0.001$, $\eta 2 = 0.02$).

Lander et al. (2017a) examined the test-retest reliability and concurrent validity between the CAMSA and the Victorian FMS Assessment (Walkley et al., 1996) among early adolescent Australian girls. The participants were 34 Year 7 females with a mean age of 12.6 years. They were tested and retested on each instrument in a school setting administered by the teachers. The results revealed excellent ICC for the overall CAMSA score, 0.91 as well as for the CAMSA time score, 0.80, and CAMSA skill score, 0.79. Additionally, there was no evidence suggesting any proportional bias in both instruments. However, the authors found evidence of strong concurrent validity ($rs = 0.68$, $p < 0.5$) between the CAMSA and Victorian FMS Assessment. The participants' CAMSA scores were compared to the CAPL-2 standards which represent

the norm for Canadian children between the ages of 8 and 12. Thus, it was revealed that 10 out of 34 girls (29.4%) were considered as “Beginning” (<21), 18 out of 34 girls (52.94%) were “Progressing” (21–24), and 6 of them (17.65%) were “Achieving” (>24–27). However, none of the girls was considered “Excelling” (>27). The authors concluded CAMSA had advantages over the Victorian FMS Assessment for having both process and product assessment, less time needed to administer, and higher authenticity.

Cao et al. (2020) evaluated the CAMSA performance as well as determined the concurrent validity of the CAMSA timing components compared to three standards agility instruments namely the Illinois Agility Test (IAT), Repeated Side-Step-1m distance (RSS-1MD), and Repeated Side Step-half of height (RSS-HHD) among a sample of Chinese male elementary school children. 149 male children (9.0 ± 0.8 years) from public schools in Shanghai, China participated in the study. The findings showed the participants’ average CAMSA completion time was 19.3 ± 5.3 (s) and the average time score was 8.7 ± 3.9 (range of 1-14). Based upon the stated purpose, the study revealed a strong correlation between CAMSA completion time with the three agility instruments: IAT, $r = 0.77$; RSS-1MD, $r = -0.76$; and RSS-HHD, $r = -0.77$, $p < 0.01$. In addition, the CAMSA time score and the three agility instruments: IAT, $r = -0.79$; RSS-1MD, $r = 0.78$; RSS-HHD, $r = 0.78$, $p < 0.01$ showed similar results whereby a strong correlation was found. Although the objective of the study was only to validate the CAMSA timing components, the inter-rater reliability of the CAMSA skill score was also analysed. The analysis revealed substantial CAMSA skill scores for timed trial 1 (ICC = 0.71, 95% CI [0.59, 0.79]) and timed trial 2 (ICC = 0.62, 95% CI [0.48, 0.72]. These results were in agreement with the Canadian study (ICC = 0.66 – 0.70) by Longmuir et al. (2017). Furthermore, similar to the study conducted by

Lander et al. (2017a), this study's CAMSA scores were also based on the Canadian norm (HALO, 2017). Therefore, 60.4% of the participants (e.g., 90 participants) were ranked as "Beginning" and "Progressing", 22 participants were considered as "Achieving", and 37 participants were "Excelling". In conclusion, less than half of the participants were able to achieve the recommended level of the total CAMSA scores ("Achieving" and "Excelling"). Therefore, the authors suggested a longitudinal study using the CAMSA protocol to be carried out on a sample of Chinese children.

CAMSA's validity and reliability among Spanish children have also been established (Menescardi et al., 2022). The study reported acceptable-to-good internal consistency ($\alpha = 0.54$ and G-coefficient = 0.88) as well as moderate-to-excellent inter-rater (ICC = 0.99 – 1.00), intra-rater (ICC = 0.99 – 1.00), and test-retest reliability (ICC = 0.70 – 0.83). The one-factor model was validated by confirmatory factor analysis (CFI = 0.95; RMSEA = 0.2; SRMR = 0.2). Furthermore, the authors found evidence of moderate concurrent validity ($r = 0.45$) between the CAMSA scores and the KTK. Similar to the findings reported by Longmuir et al. (2017), male and older age children demonstrated higher scores than female and younger age children respectively.

The CAMSA's reliability and validity in assessing the FMS performance in children between the ages of 8 and 12 have been established in various countries. Due to its higher authenticity, less time needed to administer, and having both process and product assessment, the CAMSA is an attractive alternative to assess FMS performance in children (Lander et al., 2017a). In addition, HALO (2017) highlighted that the CAMSA's objective is to evaluate the FMS required for children to participate in an active play situation. Therefore, this study used the CAMSA as an assessment tool to measure the FMS performance of Sarawakian primary school students.

2.1.2 Fundamental Motor Skills Performance

This section provides an overview of (a) gender differences in FMS (b) current FMS performance in Malaysia.

2.1.2(a) Gender differences

Several studies have reported that gender was a significant factor in determining children's FMS performance (Behan et al., 2019; Korbecki et al., 2017; Shams et al., 2021; Slykerman et al., 2016; van Stryp et al., 2022), with boys typically exhibiting superior FMS performance, particularly in manipulative skills in comparison to girls (Behan et al., 2019; Korbecki et al., 2017; Slykerman et al., 2016; van Stryp et al., 2022). Slykerman et al. (2016) assessed the FMS performance of 136 Australian children using the TGMD-2 and reported higher manipulative skills scores in boys in comparison to girls. Furthermore, Korbecki et al. (2017) also reported superior performance among boys compared to girls in manipulative skills in a study examining FMS performance among 98 children aged 6 and 7 years old in Krosno, Poland. In a study by Behan et al. (2019) on Irish primary school students' FMS performance (n = 2098, aged 5 to 12 years), the findings revealed that girls performed better than boys in locomotor and balance skills while the boys scored significantly higher than girls in manipulative skills. In addition, Shams et al. (2019) assessed the FMS performance of 2200 Iranian children aged between 2.5 and 14 years, with findings showing higher FMS performance in boys compared to girls. Likewise, van Stryp et al. (2022) reported that boys outperformed girls in manipulative skills, among 178 Grade 1 South African children using the TGMD-2.

2.1.2(b) FMS performance in Malaysia

There are limited studies on the FMS performance of primary school students that have been published in Malaysia, much alone in Sarawak. The available research

on the FMS performance of children in Sarawak primarily focused on preschool-aged children (Chung et al., 2021; Chung et al., 2022). The FMS performance of primary school students in Malaysia from the limited research available is presented in Table 2.2.

Table 2.2 FMS performance of primary school students in Malaysia

Author	Participants	FMS Assessment Tools	FMS Proficiency Levels
Baharom et al. (2014)	64 male children aged 9 years old	TGMD-2	9 years old children experienced delays in the age-equivalent locomotor score (4.61 ± 0.69), age-equivalent manipulative score (5.52 ± 0.62) and gross motor development quotient (7.26 ± 2.14).
Ariff & Ibrahim (2017)	99 children aged 7, 8 and 9 years old	TGMD-2	i. Significance difference among 7, 8 and 9 years in GMDQ scores. ii. 7 years old children's GMDQ scores were at a normal level while 8 and 9 years old were at a low level compared to their age.
Mahinderjit-Singh & Koh (2018)	160 children aged 7 years old	TGMD-2	i. Locomotor skills and manipulative skills were at an average level. ii. No significant difference was found between gender for gross motor development.
Jakiwa & Suppiah (2020)	72 children 8 and 9 years old	TGMD-2	The participants exhibited the performance of 5- and 6-years old children in locomotor skills and the performance of 6 and 7 years old children in manipulative skills.