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THE CORRELATIONS BETWEEN SENSORY PROCESSING ABILITIES AND GROSS MOTOR SKILLS AMONG CHILDREN AGED 7-10 YEARS OLD

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Pradeep Balakrishnan[1]*, Mahfuzan[2], Izham[3], Vinodhkumar Ramalingam[4]

Authors:

[1 2 3] School of Health Sciences, KPJ University, Kota Seriemas, Nilai, Negeri Sembilan, Malaysia
[4]Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Sciences, Chennai, India

Corresponding Author:

[1*]Pradeep Balakrishnan, Email: pradeep@kpjuc.edu.my/physiodeep@gmail.com

ABSTRACT

Background of the study: Children who display clumsiness, poor performance in sports or delayed motor milestones may face challenges in gross motor skills. Research has shown many factors that influences Gross Motor Skills such as BMI and physical activity participation. However, few research has shown relationships between sensory processing and gross motor skills. Therefore, this study aims to investigate the correlations between sensory processing abilities and gross motor skills among children aged 7- years old. **Methodology:** The study was conducted at a children's gym and a primary school where 56 typically developing children between ages 7-10 years old were collected. Their parents were given a questionnaire known as the Short Sensory Profile to assess the sensory processing abilities while the subjects were observed by the researcher using the Test of Gross Motor Development – 2 in order to assess the gross motor skills. **Results:** The results indicate that there is a significant correlation between sensory processing -abilities and gross motor skills among children aged 7 - 10 years old [p-value < 0.05; p-value = 0.012]. Under the short sensory profile subscales, only the under responsive/sensation seeking was found to be significantly correlated with gross motor skills [p-value <0.01; p-value = 0.003]. **Conclusion:** Child who faces challenges in gross motor skills could also likely exhibit atypical sensory processing abilities. Therefore, a child should also be screened for deficits in sensory processing when they display poor performance in gross motor skills. However, the results of this study do not imply causation.

Key words: Poor performance; Motor milestones; Gross Motor Skills; BMI

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INTRODUCTION

Childhood is an important stage where children begin to grow rapidly in areas such as social, cognitive and motor development. Motor development is especially critical for a child's physical growth and strengthening of bones, muscles and the ability to move around and manipulate his or her environment (Sharma, 2010). Motor development is categorized into part which are gross motor skills and fine motor skills. Gross Motor Skills (GMS) are essential to produce a variety of movements that enable a child to function (Payne & Isaacs, 2012). It primarily uses the large muscles in the body such as the upper body, trunk and leg muscles. GMS can be divided into 2 domains which are comprised of loco motor and object control. The movements that are involved in these 2 domains include running, skipping, hopping for loco motor skills and catching, throwing and kicking for object control (Ulrich, 2000).

Studies have shown the association of GMS with functional connectivity of the brain (Marrus et.al, 2018), as well as cardiorespiratory endurance (Okely, Booth & Patterson, 2001), in the development of social cognition, language and social interactions (Zeng et.al, 2017) and also with body mass index (D'Hondt et.al, 2009; Okely, Booth & Chey, 2004). A study by Nervik et.al (2011), concluded that children aged 3- 5 years old (preschoolers) with high BMI (ie overweight or obese) could have problems regarding their gross motor skills. Overall, GMS is an important aspect in a child's development social, cognitive and physical development.

A study by Clark (2007) stated that postural control in motor skills requires the support of the central nervous system (CNS) to monitor the body by using the sensors such as vestibular sensors, vision sensors and proprioceptors. This opens up suggestions on how sensory processes could be correlated with GMS. Sensory processes refer to the way humans receive stimuli and interprets into a response. Sensory processing abilities can be explained using Dunn's model which he explained are characteristic in every person's experience in everyday life (Dunn, 2007). Dunn hypothesized that based on interaction between a person's nervous system operations and self-regulation strategies basic patterns of sensory processing emerge.

These sensory processing patterns are made up of domains comprising of tactile sensitivity, under responsiveness sensitivity, low energy, movement sensitivity, taste/smell sensitivity and auditory/visual sensitivity. These sensory processes could have a link with gross motor skills as both of them play an important role on a child's daily life. Therefore, this research aims to study the correlations that could exist between sensory processing abilities and gross motor skills in children aged 7-10 years.

Objectives of Study: The main objective of this study is to assess the associations between sensory processing profiles and gross motor skills of children between ages 7-10 years old. To achieve this main objective, the following specific objectives constructed:

To study the correlations between each sensory profile subscales and the total gross motor skills performance among children aged 7-10 years old.

To identify socio-demographic characteristics between sensory processing profiles and gross

motor skills performance among children aged 7-10 years old.

RESEARCH METHODOLOGY

Study Design:A correlational cross-sectional study is used for this study in which the gross motor skills and sensory patterns were assessed. This design allowed the researcher to observe two variables at a time and also be used to generate hypothesis and observe multiple outcomes simultaneously without loss of follow up (Lau F, 2017).

Study Location: The selections for the location of this study are at We Rock the Spectrum (WRTS), Ara Damansara and Sekolah Kebangsaan Sri Subang. WRTS is an all-inclusive children's play gym. This location was chosen due to its vast space which is suitable to run gross motor skills assessment and also for the equipment that are readily available at the gym which are also needed to run the assessments. Furthermore, a considerable number of patrons that regularly visit the gym are children that fit the inclusion criteria for this study. Sekolah Kebangsaan Sri Subang is a primary school which is convenient to the researcher as the target group for this study are children between 7-10 years old.

Ethical Consideration: Ethical considerations were made by firmly establishing to the parents and caregivers that the participation in this study was voluntary and that no discrimination will be made to those who do not wish to participate. The purpose of this study was explained to the participants and their caregivers by the researcher and an information sheet of the study were handed out. Confidentiality and anonymity of the participants were ensured by implementing consent forms for every participant. Ethical Clearance Number: KPJUC/RMC/SOHS/ EC/2019/202.

Reference Population: The reference population of this study are children aged 7-10 years from We Rock the Spectrum, Ara Damansara and Sekolah Kebangsaan Sri Subang. The sampling frame was chosen here because of the convenience for the researcher in terms of space and equipment which are used for running the assessments.

Sampling Frame: In this study, the target population are children between ages 7-10 years old. Physical development is critical at this stage and the beginning of involvement into new situations can lead to long lasting impacts on emotional and intellectual aspects (CDC, 2017; Eccles, 1999).

Sampling Method: The sampling method chosen for this study is convenience sampling. Convenience sampling enables the research to be conducted in a fast and inexpensive way.

Sample Size Determination: Sample size was determined using Slovin's formula. In this study, a population size of 76 with a confidence interval of 95% which allows a 5% margin of error in the study was used. A population size of 76 (N) and confidence interval of (e) of 0.05 resulted in a sample size of 62. The equation below was used:

$$n = \frac{N}{(1 + Ne^2)}$$

Where: n = sample size (62), N = population size (76), e = margin of sample (0.05), 1 = constant value.

All the sample size of 62 are to undergo TGMD-2 as outcome measure for gross motor skills

assessment. The caregivers of the subjects are given the Short Sensory Profile questionnaire as outcome measure for sensory processing patterns of their children. Subjects aged 7-10 years old with no history of neurological conditions or musculoskeletal conditions are selected for this study.

Inclusion Criteria: Children aged 7-10 years old and Both genders

Exclusion Criteria: Children diagnosed with neurological conditions (Tomchek & Dunn, 2007), Children with musculoskeletal conditions and Children with disabilities

Research Tools: Measuring tape, weighing scale, 8–10-inch playground ball, 4-inch lightweight ball, Basketball, Tennis ball, Soccer ball, Softball, 4 – 5-inch square beanbag Tape, 2 traffic cones, Plastic bat and Batting tee.

Outcome Measure

Test of Gross Motor Development-2: The Test of Gross Motor Development – 2 assessment is the second and latest edition of Ulrich's assessment instrument and was released in 2000. This instrument is used to identify children between 3-10 years of age who may be behind their peers in gross motor skill development. The test assesses 12 motor skills which are further categorized into two subtests which are locomotor skills and object control skills. Locomotor skills measure run, gallop, hop, skip, horizontal jump and slide while object-control skills measures striking a stationary ball, stationary dribble, catch, kick, overhand throw and underhand roll. Reliability coefficients for locomotor subtest average is 0.85, the object control subtest average is 0.88 and the overall gross motor average is 0.91. A study conducting the reliability and validity in Malaysia found the Cronbach Alpha to be 0.82 and the validity to be 0.7 for children aged 7-9 years old (Baharom & Mansor, 2017).

The test can be administered in 15 to 20 minutes. Based on the examiner's manual, instructions to use the score sheet is given. If the child exhibits the performance criteria, they are given a score of one. However, if a zero is given if a performance criteria is not met. Using the provided test kit in the manual, raw scores are used to calculate the standard score, percentile scores, age equivalents and GMS quotient. Scoring of the GMS can be categorized into very poor, poor, typical, superior and very superior. Permission was obtained from Dr. Dale Ulrich to use the TGMD-2 assessment for this study via email.

Subtest Standard Scores	Gross Motor Quotient	Descriptive Ratings	Percentage Included
17 – 20	>130	Very Superior	2.34
15 – 16	121 – 130	Superior	6.87
13 – 14	111 – 120	Above Average	16.12
8 – 12	90 – 110	Average	49.51
6 – 7	80 – 89	Below Average	16.12
4 – 5	70 -79	Poor	6.87
1 - 3	<70	Very Poor	2.34

Source: Ulrich (2000)

Table 1: Gross motor quotient and descriptive ratings for TGMD-2 scores

Short Sensory Profile (SSP): The Short Sensory Profile was developed by Dunn (1999) as a 38 – item screening instrument that is filled in by parents which measures the functional behaviours related to sensory processing disorders (McIntosh et al, 1999). Items that are included in this assessment are functional behaviours that are prevalent in sensory processing disorders which are Tactile Sensitivity, Underresponsive, Sensitivity, Low Energy, Movement Sensitivity, Taste/Smell Sensitivity and Visual/Auditory Sensitivity. The internal reliability of SSP total test is >0.95 for children with and without disabilities. When identifying children with and without sensory issues, the validity shows the discriminant validity of the SSP as greater than 95% (McIntosh et.al, 1999). Parents are to rate their child on each item using a Likert scale of 1 (always: the child responds in this manner every time) to 5 (never: the child never responds in this fashion). Higher scores represent higher functional performance. A raw total score of each section is recorded and classified using a scoring system of typical performance, probable difference and definite difference (Dunn, 1999).

Section	Section Raw Score Total	Typical Performance	Probable Difference	Definite Difference
Tactile Sensitivity	/35	35 – 30	29 – 27	26 – 7
Taste/ Smell Sensitivity	/20	20 – 15	14 – 12	11 – 4
Movement Sensitivity	/15	15 – 13	12 – 11	10 – 3
Underresponsive/Seeks Sensation	/35	35 – 27	26 – 24	23 – 7
Auditory Filtering	/30	30 – 23	22 – 20	19 – 6
Low Energy/Weak	/30	30 – 26	25 – 24	23 – 6
Visual/ Auditroy Sensitivity	/25	25 - 19	18 – 16	15 - 5
Total	/190	190 - 155	154 - 142	141 - 38

Source: Dunn (1999)

Table 2: Sensory subtype scoring for Short Sensory Profile (Dunn, 1999)

The participants of the study were obtained using convenience sampling from WRTS gym and Sekolah Kebangsaan Sri Subang then assessed for eligibility based on the inclusion and exclusion criterion. If participants are eligible to participate in the study, their caregivers or parents are given an information sheet (Appendix I) , consent form (Appendix II) and a demographic data sheet (Appendix III) to be filled in. If consent is given, the parents are given the Short Sensory Profile questionnaire (Appendix IV) to assess the child's sensory processing patterns. Lastly, the child will be assessed in gross motor skills using the TGMD-2

(Appendix V) and a video will be taken to ensure precise observations can be made.

Statistical Analysis: The statistical analysis of the data uses the IBM Statistical Package for the Social Sciences 2.0 (SPSS). The statistical test is used to evaluate any observed difference between the numerical data is Pearson/ Spearmann correlation test. It is used because the data are parametric or continuous data. All the outcome measures in this study which are TGMD – 2 and sensory processing profiles are numerical data. Therefore, Pearson's correlation test is the most suitable statistical test for this study.

RESULTS

Descriptive Analysis: The main objective of descriptive analysis is to understand the characteristics of the subjects. These include frequency and percentages for categorical variables and median and interquartile range (IQR) for numerical variables. For this study, the collected data are a mix between categorical variables (age, gender and ethnicity) and continuous variables (tactile sensitivity, taste/smell sensitivity, movement sensitivity, under responsive/sensation seeking, auditory filtering, low energy/weak, visual/auditory sensitivity, total short sensory profile score and gross motor quotient). Out of a total of 80 questionnaires sent out, only 56 were usable with no missing data. The sample size collected did not fit the supposed 62 participants as calculated and presented in Chapter 3. This is because the location of collecting data has shut down its business and the remaining 6 participants could not be gathered in time. A summary of the descriptive analysis for the subjects are shown in Table 3.

Variables	Frequency (%)	Median (IQR)
Gender		
Male	29 (51.8)	
Female	27 (48.2)	
Ethnicity	45 (80.4)	
Malay	2 (3.6)	
Chinese	8 (14.3)	
Indian	1 (1.8)	
Others		
Age		
Short Sensory Profile (SSP)		9 (3)**
Tactile Sensitivity (TS)		
Taste/Smell Sensitivity (TSS)		171.5 (32)**
Movement Sensitivity (MS)		34 (6)**
Underresponsive/Sensation Seeking (USS)		19 (6)**
Auditory filtering (AF)		13 (4)**
Low Energy/Weak (LEW)		30.5 (12)**
Visual/Auditory Sensitivity (VAS)		28 (7)**
		29 (5)**
Gross Motor Skills (GMS)		25 (3)**
		92.5 (20)*

*Skewed to the right, **Skewed to the left

Table 4.1 Summary of the descriptive analysis (n = 56)

Gender: In this study, there are a total of 29 (51.8%) male subjects and 27 (48.2) female subjects (see Table 4.1). The percentage shows that the number male subjects are slightly higher compared to the number of female subjects.

Ethnicity: There is a total of 4 ethnic group comprised of Malay, Chinese, Indian and others based on Table 4.1. Malay subjects represent the highest number of respondents with a total of 45 (80.3%) subjects. The Chinese, Indian and 'others' ethnic groups represent the smallest number with a total of 2 (3.6%), 8 (14.3%) and 1 (1.8%) subject(s) respectively. Figure 2 below shows the ethnic groups of subjects.

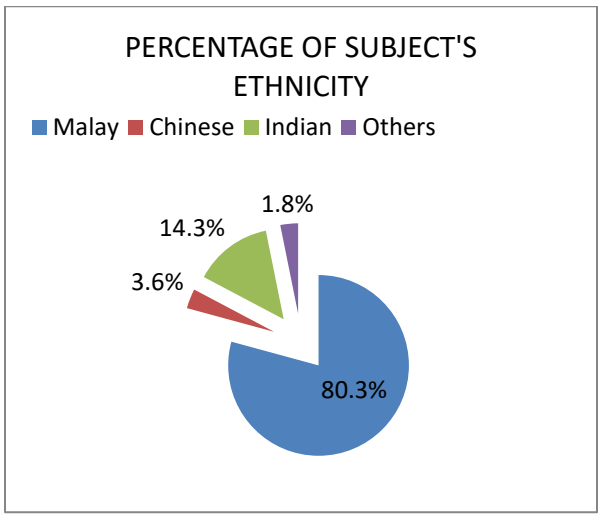

Figure1: Percentage of subject's ethnic groups

Age: Based on Table 4.1, the median and interquartile range (IQR) for age are 9 and 3 respectively. Further analysis of age using histogram and Shapiro-Wilk's normality testing shows that the data is not normally distributed (p-value < 0.05) and is skewed to the left.

Short Sensory Profile: Referring to Table 4.1, all of the SSP subscales show that the data is skewed to the left and was shown as not normally distributed (p-value < 0.05) after testing using Shapiro-Wilk's Test of Normality. The highest median under the SSP subscales is Tactile Sensitivity with a value of 34 whereas the highest IQR is Under responsive/Sensation Seeking which has a value of 12. The total value for SSP subscales median is 171.5 and while the IQR is 32. The total is also not normally distributed as the p-value is < 0.05.

Gross Motor Quotient (GMQ): The GMQ analysis indicates that the median value is 92.5 whereas the IQR value is 20. Furthermore, the Shapiro-Wilk Test p-value (< 0.05) shows that the data is not normally distributed as demonstrated in Figure 4.2 similar to SSP. However, the data is skewed to the right which indicates that the GMQ data is not normally distributed.

The collected data for correlation analysis in this study was found to be not normally distributed. Thus, in order to answer the research question stated in chapter 1, the non-parametric test for correlation analysis will be used which is called Spearman correlation. The correlation analysis was tested via Spearman's correlation and the significance level was set at the 0.05 level (2-tailed).

The strength of the relationship can be determined via the Pearson correlation (r). If the r value is 0, then it indicates no relationship between two variables and if the r value is 1, then it can be interpreted as perfect positive correlation, while if the r value is -1, it can be interpreted as negative correlation. According to the study of Cohen (1988), the r value can interpret the strength of the relationship. Table 4.4 is the guideline for the strength of the relationship according to Colton (1974). Positive values are recognized using the + symbol and negative values using the – symbol.

r - value	Strength of correlation
0.00 – 0.25	Little or no correlation
0.26 – 0.50	Fair correlation
0.51 – 0.75	Moderate to good correlation
0.76 – 1.00	Very perfect correlation

Table 4: Guidelines to Interpret R-Value

The summary for the results of Spearman's correlation analysis for total sensory processing profiles and gross motor skills including all the SSP subscales can be seen in the table 4.4.

Variables	GMS r - value	GMS p - value
SSP	0.33	0.012**
TS	0.19	0.142
TSS	0.05	0.707
MS	0.23	0.088
USS	0.39	0.003*
AF	0.14	0.289
LEW	0.16	0.222
VAS	0.18	0.185

*Significant at the 0.01 level (2-tailed), **Significant at 0.05 level (2-tailed)

Table 5: Summary of Spearman Correlation of GMS and SSP (including subscales) (n=56)

SSP=Short Sensory Profile; GMS=Gross Motor Skills; TS=Tactile Sensitivity; TSS=Taste/Smell Sensitivity; MS=Movement Sensitivity; US=Under

responsive/Sensation Seeking; AF=Auditory Filtering; LEW=Low Energy/Weak; VAS=Visual/Auditory Sensitivity

Based on the results in Table 4.5, we reject the null hypothesis since the SSP variable and GMS variable (p – value < 0.05, p – value = 0.012); the USS variable and GMS variable (p – value <0.05, p – value = 0.003). Thus, we conclude on the alternative hypothesis.

However, based on Table 4.4, we accept the null hypothesis for TS and GMS (p – value > 0.05, p – value = 0.142); TSS and GMS (p – value > 0.05, p – value = 0.707); MS and GMS (p – value > 0.05, p – value 0.088); AF and GMS (p – value > 0.05, p – value = 0.289); LEW and GMS (p – value > 0.05, p – value = 0.222); VAS and GMS (p – value > 0.05), p – value = 0.185).

However, based on Table 4.4, we accept the null hypothesis for TS and GMS (p – value > 0.05, p – value = 0.142); TSS and GMS (p – value > 0.05, p – value = 0.707); MS and GMS (p – value > 0.05, p – value 0.088); AF and GMS (p – value > 0.05, p – value = 0.289); LEW and GMS (p – value > 0.05, p – value = 0.222); VAS and GMS (p – value > 0.05), p – value = 0.185).

There is a significant correlation between sensory processing profiles and gross motor skills performance among children aged 7-10 years old.

There is a significant correlation between sensory processing profile and gross motor skills among children aged 7-10 years old ($p<0.05$, $p=0.012$). The observed correlation coefficient 'r' is 0.33 which suggests a positive and fair correlation between the variables.

TS: There is a significant association between tactile sensitivity subscale and gross motor skills performance among children aged 7-10 years old.

There is no significant correlation between tactile sensitivity subscale and gross motor skills performance among children aged 7-10 years old ($p>0.05$, $p=0.142$). The observed correlation coefficient 'r' is 0.19 which suggests little to no correlation. Therefore, TS is not correlated to GMS.

There is no significant correlation between taste/smell sensitivity subscale and gross motor skills performance among children aged 7-10 years old ($p>0.05$, $p=0.707$). The observed correlation coefficient 'r' is 0.05 which suggests little to no correlation. Therefore, the TSS is not correlated to GMS

MS: There is a significant association between movement sensitivity subscale and gross motor skills performance among children aged 7-10 years old.

There is no significant correlation between movement sensitivity subscale and gross motor skills performance among children aged 7-10 years old ($p>0.05$, $p=0.088$). The observed correlation coefficient 'r' is 0.23 which suggests little to no correlation. Therefore, MS is not correlated to GMS.

USS: There is a significant association between under responsive/sensation seeking subscale and gross motor skills performance among children aged 7-10 years old.

There is a significant correlation between under responsive/sensation seeking and gross motor skills among children aged 7-10 years old ($p<0.05$, $p=0.003$). The observed correlation coefficient 'r' is 0.39 which suggests a positive and fair correlation between the variables. Therefore, USS is significantly correlated to GMS.

AF: There is a significant association between auditory filtering subscale and gross motor skills performance among children aged 7-10 years old.

There is no significant correlation between auditory filtering subscale and gross motor skills performance among children aged 7-10 years old ($p>0.05$, $p=0.289$). The observed correlation coefficient 'r' is 0.14 which suggests little to no correlation. Therefore, the AF is not correlated to GMS.

LEW: There is a significant association between low energy/weak subscale and gross motor skills performance among children aged 7-10 years old.

There is no significant correlation between movement sensitivity subscale and gross motor skills performance among children aged 7-10 years old ($p>0.05$, $p=0.222$). The observed correlation coefficient 'r' is 0.16 which suggests little to no correlation. Therefore, the LEW is not correlated to GMS.

VAS: There is a significant association between visual/auditory sensitivity subscale and gross motor skills performance among children aged 7-10 years old.

There is no significant correlation between movement sensitivity subscale and gross motor skills performance among children aged 7-10 years old ($p>0.05$, $p=0.185$). The observed correlation coefficient 'r' is 0.18 which suggests little to no correlation. Therefore, the VAS is not correlated to GMS.

Therefore, there is a significant correlation between total sensory profile and gross motor skills among children aged 7-10 years old ($p<0.05$). However, there is no significant correlation between tactile sensitivity, taste/smell sensitivity, movement sensitivity, auditory filtering, low energy/weak, visual/auditory sensitivity, and gross motor skills among children aged 7 – 10 years old ($p>0.05$). Table 4.6 shows the summary on the status of the hypothesis of the correlation between SSP and GMS. The table also shows the status of correlations between the SSP subtypes and GMS.

HYPOTHESIS/SUBSCALE	STATUS
SSP	Supported
TS	Not significant
TSS	Not significant
MS	Not significant
USS	Significant
AF	Not significant
LEW	Not significant
VAS	Not significant

Table 6: Summary of Status of Hypothesis/Subscales

DISCUSSION

The study design uses a correlational cross-sectional study which allows for bivariate observations at one time without loss of follow up (Lau, 2017). The populations for collecting data are typically developing children from ages 7-10 years old which have been established before proceeding with observations. The data was collected using convenience sampling to reduce on time and cost constraints at two locations – We Rock the Spectrum and Sekolah Kebangsaan Sri Subang. A total of 80 questionnaires were given out to the parents to collect the 62 subjects calculated for sample size. However, only 56 subjects were collected due to issues arising with the location and also time constraints. The subjects' parents were given a consent form, demographic data form and the Short Sensory Profile (SSP) form. The SSP form is a valid and reliable 38-item questionnaire developed by Dunn (1999) to measure behavior relating to sensory processing disorders using a Likert scale. It can be further divided into 7 subscales namely tactile sensitivity, taste/smell sensitivity, movement sensitivity, under responsive/sensation seeking, auditory filtering, low energy/weak and visual/auditory sensitivity. After receiving the forms, the observations are conducted using the Test of Gross Motor Development – 2 (TGMD-2) which is used to assess the gross motor skill

development of children. The test assesses 12 motor skills measured under locomotor and object control skills. The raw scores obtained are interpreted into Gross Motor Quotient using the TGMD-2 manual by Ulrich (2000).

SUMMARY OF RESULTS

Based on the statistical analysis performed in Chapter 4, the results indicate that there is a significant correlation between sensory processing profile and gross motor skills among typical children aged 7-10 years old. Thus, the main hypothesis is supported. However, out of the seven subscales under sensory processing, only one is accepted where the result demonstrates a significant correlation between under responsive/sensation seeking and gross motor skills. The strength and direction for both these correlations are fair and positive correlations respectively. Therefore, the main objective of this study to identify correlations between sensory processing profile and gross motor skills among typical children aged 7-10 years old was achieved. The next part will delve further into the meaning of these results.

DISCUSSION OF RESULTS

In line with the main hypothesis, this study demonstrates that gross motor skills are correlated with sensory processing abilities. In other words, the higher the sensory processing abilities, the higher the gross motor skills and vice versa. This suggests that children who face challenges in gross motor skills could likely exhibit atypical sensory processing abilities. Therefore, it is important for children with difficulties in gross motor performance to be first screened for potential deficits regarding sensory processing abilities. This is because sensory processes are considered as preliminary to gross motor skills. It is derived from the brain's ability to interpret the stimuli it receives and turn the input into responses. This means that the sensory processing abilities influences on how a child behaves and responds. Thus, we can observe whether the reasons for poor/good motor skills are influenced by the sensory processes.

This allows physiotherapists and occupational therapists' alike to have valid concerns regarding the implications that sensory processing abilities could have on the gross motor skills performance. Furthermore, sensory processing interventions could prove to be useful in order to overcome the challenges faced by a child with poor gross motor skills performance. The results of this study are supported by a study conducted by White, Mulligan, Merill and Wright (2007) who discovered similar correlations between sensory processing abilities assessed using the Sensory Profile and functional motor tasks as measured by Assessment of Motor and Process Skills (AMPS). However, their study focuses on functional motor skills and assesses sensory process using the full Sensory Profile. In contrast, this study focuses on gross motor skills which are the precursor to finer and more functional motor processes and uses the Short Sensory Profile instead of the full version due to the lack of resources.

There are many correlations which exist with gross motor skills besides SSP, such as BMI or physical activity. However, SSP is a factor which can be looked at if the child has poor gross motor skills but which cannot be explained using BMI or physical activity participation. However, it is important to note that sensory processing abilities are comprised of a combination of different specific areas of stimuli which includes tactile, proprioception, auditory and so on.

Thus, the one of the specific objectives of this study is intended to determine the exact stimuli under the SSP subscales which correlate with gross motor skills.

The seven SSP subscales are comprised of tactile sensitivity, taste/smell sensitivity, movement sensitivity, under responsive/sensation seeking, auditory filtering, low energy/weak, visual/auditory sensitivity. Firstly, tactile sensitivity was found to not be correlated to gross motor skills. This finding contradicts another study as TS was found to be weakly correlated with gross motor skills, albeit the study subjects were children with cerebral palsy (Park, 2017). However, TS is the aversive or negative response of sense of touch through sensory receptors in the skin especially in the fingers and feet. This means that the sensitivity of the distal parts of the body indicates that the deficit points more towards fine motor skills compared to gross motor skills. This could explain why there was no significant correlation between tactile sensitivity and gross motor skills in this study.

Next, taste/smell sensitivity was also found to not be correlated to gross motor skills. This pairing has the highest p-value (0.707) indicating that it is the weakest correlation with gross motor skills compared to other subscales. This could be due to sensory issues relating more towards oral motor compared to gross motor skills. Therefore, there is no significant correlation between TSS and GMS. This hypothesis is in line with a study by Park (2017) where there is no correlation between TSS and GMS.

Third, movement sensitivity was not significantly correlated with gross motor skills (p – value of 0.088). This finding contradicts studies from Park (2017) and Mulligan & Wright (2007). An explanation could be that movement sensitivity is related the vestibular system which plays an important role in hand-eye coordination under fine motor skills. However, one might argue that MS is also related to postural control, motor planning and balance which are all important areas for gross motor skills (An, 2015). The sample size of the study could affect the results of this study. Therefore, in this study, MS is not significantly correlated to GMS.

Next, the under responsive/sensation seeking was found to be the only subscale that is significantly correlated to gross motor skills (p-value=0.003). The correlation was positive although weak with an ‘r’ value of 0.39. Therefore, the higher the scores under the under responsive/sensation seeking subscale, the higher the GMS. In other words, a child with low sensitivity input would most likely face challenges with gross motor skills. A similar study showed that USS was significantly correlated with GMS among children with developmental coordination disorder (Engel-Yeger & Segel, 2018). As mentioned, Chapter 2, under responsive and sensation seeking can be interpreted as opposite ends of the same spectrum which is low sensitivity input. While a child who is under responsive does nothing to fulfill the low sensitivity input, a child with sensation seeking will try to compensate their lack of input by craving for more stimuli. In short, these behaviors are derived from the same source but responds in different ways. The similarities between these behaviors in terms of gross motor skills are clumsiness, poor coordination and poor proprioception which are areas used for gross motor. Therefore, USS is found to be significantly correlated with GMS.

The fifth subscale is auditory filtering which was not significantly correlated to gross motor skills. This finding is not in line with other studies such as Park (2017) who found that AF is weakly correlated with GMS. Auditory filtering is similar with movement sensitivity because they both derived from the same vestibular system. However, auditory filtering is emphasized more on attention skills compared to gross motor skills (Robinson, Hawthorne & Rahman, 2018). Therefore, in this study, AF is not significantly correlated to GMS.

The sixth subscale is low energy/weak which was not significantly correlated to gross motor skills. Lastly, the seventh sub-hypothesis is visual/auditory sensitivity which was found not to be significantly correlated to gross motor skills.

Limitations & Future Studies: There are a few limitations in this study which must be considered when interpreting the results. Firstly, a majority of the number of subjects are Malay children which may not adequately represent the population. Therefore, generalizability should be applied with caution. Secondly, the assessment for sensory processing using the Short Sensory Profile is parent reported which may not be as accurate as a certified clinician would diagnose. However, the purpose of the SSP is used as a screening tool to be filled by proxy therefore the validity and reliability is assured. Lastly, the results from this study are considered as preliminary and although there is a significant correlation, it cannot imply any causation between sensory processing and gross motor skills.

Despite these limitations, this study shows the importance of the relationship between sensory processing abilities and gross motor skills have on the development of children. However, there are still numerous opportunities to explore this relationship from different perspectives. Therefore, future studies can also explore into any other relationships that may exist with gross motor skills to further understand a child's physical development future studies may look into the relationship between sensory processing using the full sensory profile assessment and motor development using functional and fine motor skills assessments in order to refine the scope of this study. Lastly, future studies should focus on experimental studies to determine the causal relationships between sensory processing gross motor skills.

CONCLUSION

The aim of this chapter is to give an overall description on the relationship between sensory processing abilities and gross motor skills among children aged 7-10 years old. Children between ages 7-10 years old enter a phase where their gross motor skills start to develop into more context specific skills. Therefore, since the establishment of their gross motor skills is important, it is also equally important to understand the factors that contribute to GMS. The reason why this study was conducted was to find out whether sensory processing can affect the results of gross motor skills.

Previous studies focused more on other factors relating to gross motor skills such as BMI or physical activity participation. In this study, the Short Sensory Profile is used because it is a convenient and simple screening tool to measure sensory processing. The TGMD-2 is used to specifically gross motor skills such as running, hopping and jumping as compared to other studies which uses functional or fine motor skills. Next, the results of this study showed that there is a significant correlation

between sensory processing abilities and gross motor skills among children aged 7-10 years old.

The results also indicate that the under responsive/sensation seeking subscale under sensory processing is also correlated to gross motor skills. Therefore, the results show that sensory processing abilities could have an effect on gross motor skills. Thus, by examining the sensory processing abilities in children who face problems with gross motor skills can be helpful to clarify why the child displays clumsiness, poor performance in sports or decreased physical activity participation. This study also helps to show multi-disciplinary benefits as both physiotherapy and occupational practitioners can create suitable programs that can meet the child's needs in gross motor skills.

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