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A Longitudinal Examination of the Contribution of Perceived Motor Competence and Actual Motor Competence to Physical Activity in 6 to 9 Year Old Children

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CHAPTER THREE

METHODOLOGY

The investigation was a mixed-longitudinal study, designed to track patterns and identify critical periods regarding the contribution of actual and perceived motor competence to physical activity levels in the early primary years between 6 and 9 years of age. For the current study, a single-cohort, multiple age design was employed. A sample of 6-, 7- and 8-year-olds were recruited, and followed forwards for 18 months across four data collection periods at approximately 6 month intervals.

Single-cohort, multiple age studies are complex and challenging to execute. According to Nicholson, Sanson, Rempel, Smart and Patton (2000), recruitment methods and assessment instrumentation for each age groups need to be developed and administered simultaneously, and measurement approaches need to remain consistent across all data collection periods in order to retain comparability across the sample.

This design allows for separate assessments of age effects, time of measurement effects and cohort effects. Measurement of time and cohort effects are minimal, the data from multiple cohorts collected at the same age can be combined to increase sample size and analytic power (Nicholson et al., 2000). The design has the further advantage of providing data on later developmental periods without waiting for a single cohort to mature across the full period of interest. As results are produced more quickly, there is also less concern that theories and instruments will be out of date before the results are available. Importantly, follow up of more than one age group increases the confidence in the generalisability of results (Nicholson et al., 2000). A single sample of 6-, 7- and 8-year-olds were recruited, and followed forwards for 18 months across four data collection periods, approximately 6 months apart.

Sample

The sample for this study comprised children aged 6 to 8 years old from middle socio-economic primary schools located across a geographic spread of the Perth metropolitan area. Based on Socio Economic Indices for Areas (SEIFA) (part of the Australian Bureau of Statistics), twenty schools from middle socio economic areas were invited to participate in the study. Eleven schools agreed to take part in the study.

Both boys and girls from these schools were invited to be part of the study if they were aged 6, 7 or 8 years between January and June 2005, and were of good health status. Children were ineligible if they were medically unfit or suffered from any ill health that prohibited them from participating in physical education classes at school. No specific response rate was obtained as the schools were responsible for the distribution of the research information and invitations to eligible children.

Two hundred and one participants (89 females and 112 males) were initially recruited for the study in November and December 2004. The study was planned based on a continuous response (physical activity step count) dependent variable from an independent group of subjects. In a previous study (Hands & Parker, 2008), the response within each subject group was normally distributed with standard deviation of 2,500 steps. If the true difference in males and females is 2,000 steps, the current study needs 26 male subjects and 26 female subjects in each age group to be able to reject the null hypothesis that the population means of males compared to female groups are equal with probability (power) 0.8. The Type I error probability associated with this test of this null hypothesis is 0.05.

Four data collection periods (February to March 2005 and 2006, and October to November 2005 and 2006) assessed the children across 18 months, with approximately 6 months between each data collection. Attrition was low (2.5%) with one participant withdrawing from the study and four other participants moving schools after the first data collection. Sample size for each data collection cycle varied depending on school attendance on the testing day and complete data set for each participant depended on diligence in returning pedometer diaries for the physical activity measure.

Figures 2 and 3 present the sample breakdown for male and female participants across all four data collection cycles. The figures represent the number of children tested at each data collection cycle. If participants were absent in data collection one (DC1), they were still included in the study for subsequent data collections. Hence, attendance for 8-year-old boys and girls increased from DC1 to DC2 (Refer to Figure 2 and 3). Data collected from the sample at the same age were combined to increase sample size and analytic power during data analysis and reporting of results. For example, when the findings for 7-year-old boys and girls are reported, this refers to 7-year-olds from data collection cycles one and two (DC1 and DC2), and 6-year-olds who turned 7-years-old during data collections three and four (DC3 and DC4). The same applies to the 8-year-olds boys and girls (8-year-olds from DC1 and DC2, and 7-year-olds turning 8 years old in DC 3 and DC4) (Refer to Figure 2 and 3).

Age	**DC1**	**DC2**	**DC3**	**DC4**	**Total**
6	33	29	-	-	62
7	39	38	35	32	144
8	29	35	37	37	138
9	-	-	27	32	59
Total	101	102	99	101	**403**

Figure 2. Breakdown of male sample attendance across age and data collection cycles.

Age	DC1	DC2	DC3	DC4	Total
6	23	25	-	-	48
7	26	25	21	21	93
8	29	35	26	25	115
9	-	-	28	31	59
Total	78	85	75	77	**315**

Figure 3. Breakdown of female sample attendance across age and data collection cycles.

Measures

The primary instruments for gathering data for this study were pedometers and diaries for physical activity, the Self Description Questionnaire - I (SDQ-I, Marsh, 1988; 1990) for PMC and the Fundamental Movement Skills Teacher Resource Manual (EDWA, 2001) for AMC.

Physical activity

Pedometers (Yamax SW-200) were used to record daily step counts over a 7 day period. Previous research has found the pedometer to be a reliable measure of physical activity in young children (Bassett et al., 1996; Hands, Parker & Larkin, 2006). Schneider, Crouter and Bassett (2004) compared step values of multiple brands of pedometers over a 24 hour period in measuring free living physical activity. They concluded that five pedometers, including the Yamax SW 200, appeared to give similar values for step counts per day and were suitable for applied physical activity research.

Tudor-Locke, Williams, Reis and Pluto (2002) examined convergent validity through correlation between pedometers and self-report physical activity as low to moderate (r = .0.33). However, they state that an opportunity exists to study combinations of objective and subjective measures of physical activity. In a follow up paper, Tudor-Locke, Williams, Reis and Pluto (2004) also provided evidence for construct validity of pedometers to measure physical activity. In a review of previous work, they reported a small inverse relationship between pedometer-determined physical activity and age, and pedometers and body mass index (BMI). The combined evidence of construct and convergent validity provide support for using the simple and inexpensive pedometers in both research and practice. Self-report measures can provide important contextual information not provided by motion sensors and physical activity data may be better interpreted from multiple perspectives (Tudor-Locke, et al., 2002; Hands, et al., 2004). Therefore, whilst the pedometer records number of steps as a measure of physical activity, the diaries asked parents and children to record both type and frequency of activities over a 7 day period (Refer to Appendix A for example of records from a weekday and weekend).

Participants were required to wear a pedometer for 7 days. The step counter was expected to be worn during waking hours and only taken off when swimming, bathing or sleeping. Participants, with assistance from parents, were required to fill out a diary at the end of every day over the 7 day period. Activities for the day were listed in the diary for time spent before school, recess, lunch, after school, and any physical education or fitness classes and the number of steps recorded that day noted by parents in the diary. Each day the children and parents reported the amount of time they did not wear the pedometer and why. In cases where the child was involved in an activity where a pedometer was not possible or advisable (such as swimming), the responses were converted into steps and added to the daily step count. All conversions were based on 'activity duration' (min) x 120 steps (Tudor-Locke, Kasse, Williams & Reiss, 2002). This physical activity diary and conversion method has been used in other studies (Hands et al., 2004).

Perceived motor competence

The Self Description Questionnaire-I (Marsh, 1988; 1990) is designed to measure multiple dimensions of self concept and was used to measure perceived motor competence. The SDQ-I assesses three areas of academic self concept (Reading, Mathematics, and General School self concept), four areas of non-academic self concept (Physical Ability, Physical Appearance, Peer Relationships, and Parent

Relationships) and General Self Concept scale. Research with the SDQ-I strongly supports the multidimensionality of self-concept (Marsh, 1987; 1988; Marsh & Shavelson, 1985). Numerous factor analyses of responses by boys and girls of different ages have shown the SDQ-I factor structure to be stable across ages and across sex (Marsh, 1988).

The SDQ-I was selected for the current study as it is one of the few assessment items that has been proven reliable and validated for use with Australian children aged 5 to 8 years old (Marsh et al., 1991). Marsh et al.(1991) reported a central finding of support for the use of the individually administered SDQ-I with children younger than 8 years, with factors within the SDQ-I previously identified in responses by older children, also identified by younger children, indicating that self-concept factors are better defined in younger children than were previously assumed. Within the current study, three areas of non-academic self concept were measured, Physical Ability, Physical Appearance and Peer Relationships. The use of selected subscales, within the SDQ-I is acceptable (H. Marsh, personal communication, 19 December, 2004). Participants answered closed questions in the form of scaled responses based on a Likert-type scoring system of 1 to 5 and a total score out of 120 (Refer to Appendix B).

Perceived motor competence (Physical Ability, Physical Appearance and Peer Relationships subscales) was assessed after the AMC assessment, in one on one interviews with participants using the SDQ -I. The researcher recorded answers on the interview questionnaire.

Actual motor competence

Actual motor competence was assessed based on the quality of motor skill performance using criteria based on a proficiency model to analyse performance. Skill observation records from the Fundamental Movement Skills Teacher Resource Manual (Education Department of Western Australia, 2001) were used to assess the quality of motor skill performance (Refer to Appendix C).

The FMS Manual (2001) is a resource developed to assist teaching fundamental movement skills such as body management skills, locomotor skills and object control skill. For the present study, one explosive locomotor skill (standing broad jump), a continuous locomotor skill (50m run), an object control skill (overarm throw), and a body management skill (line walk) were assessed. Participants were videoed performing each skill for the analysis of performance quality and increased reliability of assessment. The researcher, having had extensive training and previous research experience in the qualitative assessment of motor skills, reviewed the video performance of each skill to avoid inter-rater unreliability. A score of 1 was recorded for each criterion successfully demonstrated and a 0 recorded if mastery of the criterion was not displayed. The run comprised six criteria, the overarm throw seven criteria, the standing broad jump eight criteria, and the line walk five criteria (Refer to Appendix C for examples of the skill criteria). A total AMC score of 26 was possible from the combination of all 4 skills criteria. This construction of a composite motor skill score has been used in previous Australian research in the assessment of motor skills (Okely et al., 2001a; 2001b; Harten, Olds & Dollman, 2008).

The process-oriented assessment of fundamental movement skills was used in preference to product-oriented because it more accurately identifies topographical aspects of the movement (Ulrich, 1999). This methodology was adapted from previous assessments of movement skills in Australian adolescents (Okely et al., 2001a; 2001b).

Type of play choices

Additionally, open ended questions were included at the end of the SDQ-I to gather information on the type of activities participants liked best (Active games vs. something else) (Refer to Appendix B). Those activities were coded as 1) Organised, competitive games or training such as basketball, netball, cricket, football, 2) informal play or games such as skipping, playground, shooting baskets, 3) sedentary play such as computer, x-box, watching television.

Data Collection and Procedures

Data were collected from the sample on four occasions over an 18 month period, with approximately a 6 month gap between each data collection. The first two data collection cycles occurred in 2005 and the final two took place in 2006.

A research assistant was employed to assist with collection for the AMC phase of the study. The research assistant signed a confidentiality agreement acknowledging training received and agreement to adhere to strict protocol regarding behaviour, language and techniques when videoing participants performance of skills (Refer to Appendix D).

Where possible, the order in which school visits occurred was replicated through each data collection period to ensure the time between each collection was around 6 months. However, at times it was unavoidable for the order to be interrupted as the testing days often had to accommodate such events as school carnivals and school holidays. Nevertheless, the time period between each collection at each school only varied by no more than 1 to 2 weeks either side of the 6 month mark.

Data collection took place between 9am and 3pm on school days. Actual motor competence was assessed first after the morning bell and was completed just before recess. This was primarily undertaken on the school oval as a large space was required for performing the motor skills. Depending on the number of participants within the school, 5 to 10 participants were brought out at a time and separated into two small groups. One group performed the 50m run and overarm throw, whilst the other group performed the standing broad jump and line walk. On completion of the first two skills, the groups swapped over, then returned to class once all four skills had been completed. The next group of participants was then collected and the procedure repeated. The largest number of participants recruited within any school was 30, with the smallest being seven.

The PMC questionnaire was completed during an interview between the researcher and the participant. The interviews were conducted in a quiet place, usually just outside the classroom and answers recorded on the interview questionnaire. Once the interview was completed, participants were handed a pedometer and physical activity diary and given instructions for the use of these instruments. Written instructions for parents were sent home with the child. The 7 day period for the pedometer usually commenced immediately following the data collection at the school. The researcher then returned to the school after 7 days and collected the pedometers and diaries. One or two follow up visits were required when children forgot to return these items.

These procedures were then repeated on three further occasions. Methods, assessment instrumentation and order of testing of AMC before PMC remained consistent across all four DC cycles.

Treatment of Data

Data screening for outliers was conducted by running frequencies on data following each DC. Outlying scores were identified and if it was possible to trace back and determine the error, scores were corrected. Where outlying scores were not due to error, they were removed, and subsequently treated as missing data. For the pedometer data, improbable records of step counts below 1,000 and above 40,000 steps were deleted (Hands, et al., 2004), only two cases of outliers (0.3%) across the four data collection cycles were removed.

Combining all four collection cycles resulted in a sample size of 718 cases in the main data file. When reviewing missing data within the variables, there were 3.3% of PMC scores missing, 1.8% of AMC scores missing and 33.2% of physical activity step counts missing. As reported earlier, pedometers and physical activity diaries given to children were occasionally not returned. The return rate of pedometer data decreased across the four data collection cycles and will be reported in the next chapter.

For longitudinal studies, missing cases and missing data present a difficult problem for analyses. If incomplete sets of data were omitted, three problems arose. The consequent waste of resources, decrease in statistical power, and the possibility that children with missing data may be systematically different from those who have complete data sets (e.g., may be less motivated or have different activity patterns). In contrast, the alternative method of replacing missing data using a group mean or group regression approach presents a different problem. If information on a group is used to determine the score attributed to an individual, then the appropriateness of using a child's data for individual interpretation is questioned (Rowe et al., 2004).

According to Rowe et al. (2004), an individualised procedure could be used to replace data more accurately than traditional group-centred methods such as replacement with group mean or regression. In this study, if a participant had recorded step counts in at least two of the four data collection cycles, that participant's mean step count would replace the missing pedometer data. A participant case was deleted if none or if only one data collection cycle included pedometer data. Rowe et al. (2004) did not recommend replacing missing data based on only one data point.

In support of this procedure, Rowe et al. (2004) found that 79 out of 299 children (26%) had incomplete data over a 6 day data collection period. Two analyses were conducted to determine whether replacement of the missing data had altered the reliability or means of the data. First, the mean step count for children whose missing data were replaced was not significantly different from the mean for the children with complete data. Means and standard deviations of the combined data (replaced and originally complete data) were similar to those of the original complete data. In addition, reliability estimates for replaced data were only slightly higher than for complete data, which would be expected because replaced data points were estimated from the remaining data points. Combining the replaced data with the complete data also increased the reliability estimates slightly. Overall, Rowe et al. (2004) demonstrated that an individual data-replacement procedure resulted in more reliable data, and that when this method was applied, children who had missing data were similarly active to children who had complete data.

Therefore in the current study, participants who were missing more than two cycles of pedometer data were deleted and participants who were missing data in one or two collection cycles had their data individually replaced. Using these procedures the original data file of 718 cases reduced to 589 cases (82%) with complete data for analysis. For separate perceived and actual motor competence descriptive analysis, 711 cases remained with full data sets. Those original cases that were missing PMC scores (3.3%) and AMC scores (1.8%) were children who also had more than two cycles with incomplete pedometer data and hence were deleted.

Data Analysis

SPSS version 17.0 was employed for all data analysis conducted for the current study. For initial statistical tests, normality of the distribution of scores for key variables was assessed separately for males and females within age groups. This strategy is recommended when analysing and comparing scores between groups (Pallant, 2005). Despite the overall high scores of PMC, when the distribution of males and female scores (for AMC and PMC) and step counts (for physical activity) within separate age groups was analysed, the distribution output was normal, therefore no transformation of variables was necessary and standard parametric tests were performed. Descriptive data, the means and standard deviations from each participant's physical activity recordings, PMC and AMC assessment were determined. An independent samples t-test was conducted to compare mean scores for males and females at each age group for all variables and Cohen's *d* was calculated to indicate effect size (magnitude of difference between boys and girls). Cohen (1992) suggested that effect sizes of 0.2 are small, 0.5 are moderate, and above 0.8 are large.

Standard linear multiple regression analysis was used to assess the relationship between physical activity (dependent variable) and PMC and AMC (independent variables), determining how well variables (perceived and actual motor competence) predicted physical activity levels and which variable was the best predictor of physical activity. The data collection cycles (DC1, DC2, DC3, DC4) were combined to investigate the contribution of perceived and actual motor competence to boys' and girls' physical activity at different ages. The 6-, 7-, and 8-year-old boys and girls became 7-, 8- and 9-year-olds between DC2 and DC3, therefore the 7- and 8-year-old age groups are represented across all four data collections. In comparison, 6-year-olds are represented from DC1 and DC2, and the new age group of 9-year-olds are represented from DC3 to DC4 (Refer to Figure 2 and 3). According to Tabachnick and Fidell (2001), multiple regression makes a number of assumptions about the data and is not forgiving if these assumptions are violated. Tests for multicollinearity (relationships amongst independent variables), normality, linearity, homoscedacity (variance of residuals about predicted dependent variable) and independence of residuals were all conducted. Based on cut off points and recommendations from Tabachnick and Fidell (2001), results revealed there were no violations of assumptions.

For the longitudinal analysis a linear mixed model (LMM) was performed to model the trajectory of physical activity over time from the first to the fourth data collection cycle. LMM are statistical models for continuous outcome variables (e.g. physical activity) in which residuals are normally distributed but may not be independent or may have constant variance. They are well suited to longitudinal and repeated measure studies, where subjects are measured repeatedly over time, or under different conditions, and there is likely correlation. LMM provide for estimation of covariance parameters which capture this correlation, as well as allowing subjects to have missing time points. Model selection involves repetitive investigations, combining a balance of statistical and subject considerations, until the simplest model with the best fit to the data is found (West, Welch, & Galecki, 2007).

Fixed effects are the independent covariates in LMM, and may be either continuous such as age, or a factor (categorical) such as gender. Within the model it includes all levels or conditions of interest. The fixed effects describe the relationship (contrasts or differences) between the independent covariate(s) and the dependent variable (West et al., 2007). A covariate is a variable that is either of direct interest or a confounding or interacting variable that is possibly predictive of the dependent variable within the LMM.

Random effects are levels of a factor in LMM, where the level sampled is not of intrinsic interest (e.g. classroom samples from a school). "Random effects are represented by (unobserved) random variables" (West et al., 2007, p.1). This includes a random sample of the possible levels or conditions of interest. These effects are specific to 'clusters' or subjects within a population, and represent random deviations from the relationship of fixed effects.

According to West et al. (2007), there are a number of advantages of LMM in longitudinal analysis, particularly over traditional repeated-measures ANOVA. These include provision for estimation of covariance parameters, allows for subjects with missing time points (i.e. unequal measurements over time for individuals), capacity to include all observations available for all individuals in analysis, cope with missing data at random, and allows for inclusion of time-varying covariates (in addition to time covariate).

Likelihood Estimation, Covariance Structure type and Comparing Models using Information Criteria

The most common types of estimation used for fixed effect parameters are Maximum Likelihood Estimation (ML) and Residual Maximum Likelihood Estimation (REML). ML "obtains estimates of unknown parameters by optimising a likelihood function" (West et al., 2007, p. 25) that is, values of the parameters that make the observed dependent variable values most likely. However ML does not account for the loss of degrees of freedom, whereas REML produces unbiased estimates of covariance parameters so therefore is often preferred (West et al., 2007). For this research data, REML statistical output was used for estimation of fixed effects parameters.

The covariance structure informs the final mixed model the shape of the variance covariance matrix between the random parameters or repeated measures with subjects. The covariance structure type specifications in repeated measures are used to specify the assumptions about the repeated measures error covariance, with different assumptions affecting the calculation of estimates. Too simple assumptions will increase Type I errors, while over complex structures will increase Type II errors. The selection of the best model is via 'goodness of fit' statistics, which in SPSS involves the information criteria results. Information criteria is based on the optimum log-likelihood statistic. It allows you to select the subset of interrelated predictors that best capture the effect of a single underlying construct (Singer & Willet, 2003; West et al., 2007). Two ad hoc criteria, based on the log-likelihood statistic allow the comparison of 'goodness of fit', namely Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The AIC parameter is based on the number of model parameters, while the BIC includes the number of model parameters plus sample size (Singer & Willet, 2003). Within the current study, the AIC was used for comparison of 'goodness of fit' for each model (Singer & Willet, 2003; West et al., 2007).

For the LMM analysis of the data within the current study, the four data collection cycles were the repeated measures. The effects of age, gender, school, PMC and AMC on physical activity over time were investigated. Physical activity was treated as the dependent variable, with Gender, Age, School, PMC and AMC treated as factors (fixed effects). School was also examined as a random effect. The final model is determined through various combinations of fixed and random effects and their interactions, until the model with the best fit to the data is found, with model diagnostics performed.

Ethical Clearance

Permission to conduct the study was granted by University of Notre Dame Australia Human Research Ethics committee. After gaining permission from school principals, voluntary informed consent was obtained from the parents or guardians of children willing to participate in this study and children were required to print their name or sign willingness to participate on the parent consent form. Assurances were made to parents and children that they were free to withdraw at any time (Refer to Appendix E).