Physical literacy in children and youth

Tanya R. Kozera

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Abstract

Background

Physical literacy has recently been adopted in PE, sport and recreation as a means to develop active participation in Canada. Physical literacy (PL) has been defined as the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life (IPLA 2015). There are three proposed domains (physical, psychological, and behavioural) for PL. Given the early stage of implementation there is a paucity of information about PL in children and youth.

Aims

The first aim was to characterize PL in children and youth, and to relate PL to health related fitness, performance and physical activity. The second aim was to evaluate a PL intervention (Run Jump Throw) in grade 3/4 physical education.

Methods

Design: Cross-sectional (n=299, grades 3, 4, 8 and 12) and quasi-experimental intervention (n=199, 4 intervention and 4 matched comparison schools, Grade 3 and 4, Run Jump Throw Intervention, 8 week).

Instruments: Physical Literacy Assessment of Youth tools (PLAY Fun, PLAY Self, PLAY Inventory), BMI, waist circumference (WC), 20 meter shuttle run (CVFIT), sprint speed (SPEED), accelerometer measured physical activity (PA), Physical Self-Description Questionnaire (PSDQ) and the Motivation to Physical Activity Measure (MPAM).

Results

Motor competence and movement vocabulary increased with grade ($p<0.01$). Curricular expectations for movement competency in grade 4 were not achieved. Substantial gaps (3.4% object control) in motor competence between males and females (M>F, $P<0.01$) were identified in grade 4, this gap widened with grade (16.6% by grade 12). Motor competence was correlated ($p<0.01$) to -0.29 WC, -0.48 BMI, 0.54 PA, 0.56 CVFIT, 0.86 SPEED, 0.23 MPAM, and 0.5 PSDQ. The affective/cognitive domain of PLAY Self was correlated to ($p<0.01$) to -0.22 BMI, 0.33 PA, 0.42 PLAY Inventory, 0.46 CVFIT, 0.45 SPEED, 0.44 MPAM, and 0.79 PSDQ. A moderate association ($r=0.51$) was observed between the physical and psychological domains of physical literacy. PLAY Self demonstrated very good convergent validity with PSDQ and MPAM. The Run Jump Throw intervention significantly improved motor competence over time (5.5%, $p<0.01$), and motor competence was greater than the SES matched comparison schools (3.5%, $p<0.05$).

Conclusion

Physical literacy shows appropriate linkages to health related outcomes in two key domains, physical and psychological. The gender gap in physical and psychological differences is alarming, and requires studies aimed at remediation. These results support the notion that PL may be a gateway to physical activity in youth, and that PL can be enhanced by means of quality PL enriched lesson plans in schools.

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Introduction

The physical inactivity prevalent in today's society has proven to be a difficult one to modify. Despite the publication of physical activity guidelines (Tremblay, Warburton et al. 2011) and long lasting public awareness campaigns such as ParticipACTION (ParticipACTION 2016) few children and youth are successful in attaining or maintaining physically active lifestyles (Nader, Bradley et al. 2008, Troiano, Berrigan et al. 2008, Colley, Garriguet et al. 2011). The percentage of children attaining the recommended 60 minutes of daily moderate to vigorous physical activity (MVPA) falls from roughly 42% to 7% as they transition into adolescence (Nader, Bradley et al. 2008, Troiano, Berrigan et al. 2008, Colley, Garriguet et al. 2011). For adults, the activity levels are even lower, with only 5-15% of Canadian adults (Colley, Garriguet et al. 2011) attaining the guideline recommendations of 150 minutes of MVPA per week. Similarly, only 3.5% of American adults attain this goal (Troiano, Berrigan et al. 2008).

Physical inactivity contributes to the burden on the health care system with the increased prevalence of health conditions such as cardiovascular disease, cancer, osteoarthritis, obesity and depression (Reilly, Methven et al. 2003, Lee, Shiroma et al. 2012). For inactive children and youth, an increase to the rise of childhood obesity and early onset diabetes has been observed (Reilly, Methven et al. 2003, D'Adamo and Caprio 2011, Dhar and Robinson 2016), as well as the increased risk of injury while participating in sports and recreational activities (Bloemers, Collard et al. 2012). The loss of quality of life and even early death (Lee, Shiroma et al. 2012, Nike 2013, Li 2014) due to obesity and physical inactivity has resulted in not only greater costs to the health care system (Katzmarzyk, Gledhill et al. 2000, Katzmarzyk and Janssen 2004, Hollander and Mechanick 2008, Pratt, Norris et al. 2014, Carlson, Fulton et al. 2015) but to individual personal finances as people take time off from work due to inactivity related health issues (Katzmarzyk and Janssen 2004) or as they attempt to manage their health conditions with multiple or often unproven methods (Barnes PM 2007, Hollander and Mechanick 2008). The health care burden in combination with the associated personal tragedy and loss of productivity, has made physical inactivity one of the most serious threats on society. The benefits of physical activity, however, for the improvement of and prevention of these health issues are well known (Warburton, Nicol et al. 2006, Reiner, Niermann et al. 2013, Ontario Agency for Health Protection and Promotion (Public Health Ontario) 2014) if only people would engage in it. What then is the barrier to a physically active lifestyle? Could there be a missing link that supports engagement in physical activity? Movement competence has been proposed as a critical link that supports participation in physical activities, yet the relationship between these, while present, has been found to be weak (Lubans, Morgan et al. 2010, Poitras, Gray et al. 2016). This weak linkage may in part be due to the tools used to assess motor competence or due to a yet unknown factor. Physical literacy is an emerging concept that supports the development of movement competency in the context of psychological factors like confidence and motivation, as a key element to achieving active participation (Whitehead 2001, Whitehead 2010, Taplin 2013). Proponents of the concept believe that physical literacy rather than movement competence alone is the missing link that supports engagement in physical activity (Higgs 2010, Whitehead 2010, Taplin 2013).

Historical Development of the Physical Literacy Concept

One of the earliest uses of the term “physical literacy” was in the late 1800’s (Maguire and United States Army Corps of Engineers 1884) where physical literacy was used to reference movement competency in a social setting. In the 1930s, the term resurfaced in the context of the educational system (Nebraska State Education Association 1931, National Education Association of the United States. Dept. of Secondary Teachers 1935, British Institute of Adult Education and National Institute of Adult Education 1937) and cited as a core educational requirement that was just as important as ‘mental literacy’ in order to graduate from grammar and high schools. Concerns about the effect of mechanization and automated processes on health and the development of new disease issues related to the loss of physical literacies were evident at that time as well (National Education Association of the United States. Dept. of Secondary Teachers 1935). The Canadian Association of Health and Physical Education, and Recreation (CAHPER), now known as Physical Health Education (PHE) Canada, in 1958, entered the discussion stating that increased physical literacy or ‘greater motor skill’ was necessary to facilitate physical activities beyond walking (Canadian Association for Health 1958). In the 1960’s, physical literacy was again identified as movement competency or proficiency in motor skills, stated to be distinguishable from physical fitness, yet necessary for both fitness and physical activity (Kelly and Stafford 1965).

Then in 1969, George Morrison proposed that “*To be physically literate, one should be creative, imaginative, and clear in expressive movement, competent and efficient in utilitarian movement and inventive, versatile, and skillful in objective movement. The body is* *the means by which ideas and aims are carried out and, therefore, it must become both sensitive and deft"* (Wall 1994). Physical literacy continued to be consistently referenced as a requirement for physical activity and fitness and necessary for health during the 1960's and 70's.

The Definition of Physical Literacy

Dr. Margaret Whitehead spurred a renewed interest in physical literacy (Whitehead 2001) when she resurrected the term and its association to physical activity and a healthy lifestyle. She was the primary host of a Physical Literacy Conference in 2011 at the University of Bedfordshire, in Bedfordshire, United Kingdom and in 2014 was a co-founder of the International Physical Literacy Association along with the Canadian Sport for Life organization (International Physical Literacy Association 2015). Whitehead proposed that physical literacy enriches life as a whole and is unique to each individual (Whitehead 2001), and supports the life-long pursuit of physical activity. According to Whitehead, a repertoire of movement capacities would continually evolve and shape each individual physical literacy journey (Whitehead 2001). Margaret Whitehead's philosophical background led her to offer a pluralistic definition of physical literacy, *"Physical literacy is the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life."* (International Physical literacy Association 2015). In the creation of this definition, the psychological components of PL were explicitly included, and as a result PL was "more than just fundamental movement skills". Other organizations have created contextual definitions. For instance, a consultant team working for Physical and Health Education Canada created an educational contextual definition, *"Individuals who are physically literate move with competence and confidence, in a wide variety of physical activities and in multiple environments that benefit the healthy development of the whole person."* (Physical and Health Education Canada 2014). Canadian Sport for Life (CS4L) offered a description of a physically literate person *"Physical literacy is the cornerstone of both participation and excellence in physical activity and sport. Individuals who are physically literate are more likely to be active for life"* and then defined it as "*Physical Literacy is the mastering of fundamental movement skills and fundamental sport skills that permit a child to read their environment and make appropriate decisions, allowing them to move confidently and with control in a wide range of physical activity situations".* In the United States, Project Play was conceived as part of the Aspen Institute to create a model, strategic plan, and a call to action under the physical literacy banner. A strategic document was released in June 2015 which offered a definition based upon the IPLA one that was designed to be palatable by the American public "*The ability, confidence and desire to be physically active for life".*

Just like the literacy field, a host of definitions have arisen and been contextualized into the sectors that they have arisen from. Certainly, despite variations in proposed definitions, there is an acceptance of motor competence as the hub with inter-related key psychological componentry including, but not limited to confidence and motivation.

The Canadian Physical Literacy Consensus Statement

There has been some limited critical assessment of the physical literacy concept, Giblin and colleagues have cited the rapid adoption of PL into physical education, sport and physical activity programming as problematic (Giblin, Collins et al. 2014). The adoption of PL has preceded evidence that PL interventions can meet the expectations lauded on it. Other critics in physical education question the difference between a physically educated and a physically literate student, and express a concern about a possible shift from physical to more psychomotor to cognitive outcomes in physical education curriculum (Lounsbery and McKenzie 2015).

As with many emergent terms, there has been confusion and interchangeable use of term physical literacy with “physical activity”, “fundamental movement skills” and “physical education”. To be clear, however, it is generally accepted that physical literacy comprises several interactive and inter-related elements of the mind, the body and the psychosocial attributes of an individual (Castelli 2015). This dynamic interaction of sensory, cognitive, motor and musculoskeletal systems with the physical environment creates an entity greater than the sum of its individual parts (Jurbala 2015). Attempts to characterize PL as movement competence in isolation of the psychosocial and cognitive elements of PL is a common misrepresentation of the concept (Jurbala 2015). Outcomes of PL are articulated as greater physical activity and participation, increased enjoyment of life and better health (Whitehead 2010, Jurbala 2015).

To provide clarity regarding the concept of physical literacy, the Canadian Physical Literacy Consensus Statement (International Physical Literacy Association 2015), was developed collaboratively between multiple agencies within Canada and the International Physical Literacy Association. This consensus statement was adopted at the International Physical Literacy Conference in Vancouver 2015. This consensus statement itemized that physical literacy included the following key components; physical competence, affective & cognitive components of psychology, and behavioural. Affective elements include the motivation and confidence to be physically active; physical elements refer to an individual's ability to develop movement skills and patterns; cognitive elements include the knowledge and understanding to understand the health benefits of an active lifestyle; and behavioural elements refer to engagement or participation in physical activities. As such, three key sub-domains of physical literacy are identified; physical, psychological (affective and cognitive) and behavioural.

Despite the existence of a consensus statement on physical literacy in Canada that aligns with others countries, there continues to be concerns expressed over how to scientifically define the concept. In part, the consensus statement has led to further questions regarding the concept, as is natural for an emerging concept. For example, there is debate about the inclusion of physical activity within the definition of physical literacy (Cairney 2016, Corbin 2016) or whether physical activity is an outcome of being physically literate. Is physical activity not an entity of itself? Others propose that the physical literacy construct also include physical fitness and body composition (Tremblay 2010, Longmuir, Boyer et al. 2015). Are fitness and health measures not entities of themselves? This debate about the nature of physical literacy, now removed from the original use of the term in the early 1900's, unfortunately, is fuelled by a lack of scientific investigation about physical literacy. This struggle is certainly expected in the early years of an emerging concept, but it is essential to commence scientific studies to provide evidence informed development of the concept.

In order to sort out the conceptual issues regarding physical literacy, construct validity testing the physical literacy construct was performed (Cairney 2016). The physical literacy model that was returned included: competence in land based movement skills; perceived movement competence; motivation; enjoyment of physical activity; and self-knowledge of health. Interestingly, physical activity and fitness were identified as separate variables and not included in the overall model. The findings of the study supported the notion of elements of physical literacy that is consistent with the earlier conceptual definition (Whitehead 2001, Higgs 2010, Whitehead 2010) plus a new factor of 'enjoyment' as key elements of physical literacy. Movement competence equally loaded with the psychological elements onto this model of physical literacy. As such, the assessment of physical literacy should include both the physical and psychological domains to sufficiently evaluate the construct. Based upon the work of Cairney and colleagues (2016), physical activity, leisure participation, fitness, performance and body composition measures are considered independent and separate variables that may be outcomes.

The Physical Literacy Cycle

An interesting concept fostered by Liz Taplin at the 2013 International Physical Literacy Conference in Banff, Canada was the notion of a *physical literacy cycle*. This positive feedback cycle, based in part on Whitehead's work, depicted a continuous positive feedback cycle between elements of motivation, confidence and movement competence (Taplin 2013). Each of these three elements was proposed to be critical to support an individual's ability to participate in physical activities. It was proposed that interventions that effectively target each of these elements, rather than just movement skill development alone will truly foster self-determined active participation. The physical literacy cycle proposed by Taplin (Taplin 2013), creates linkages between the physical (motor competence) and the psychological affective (confidence and motivation) domains. A modified version of Taplin's physical literacy cycle is shown in Figure 1 where the physical, psychological and behavioural domains are overlaid.

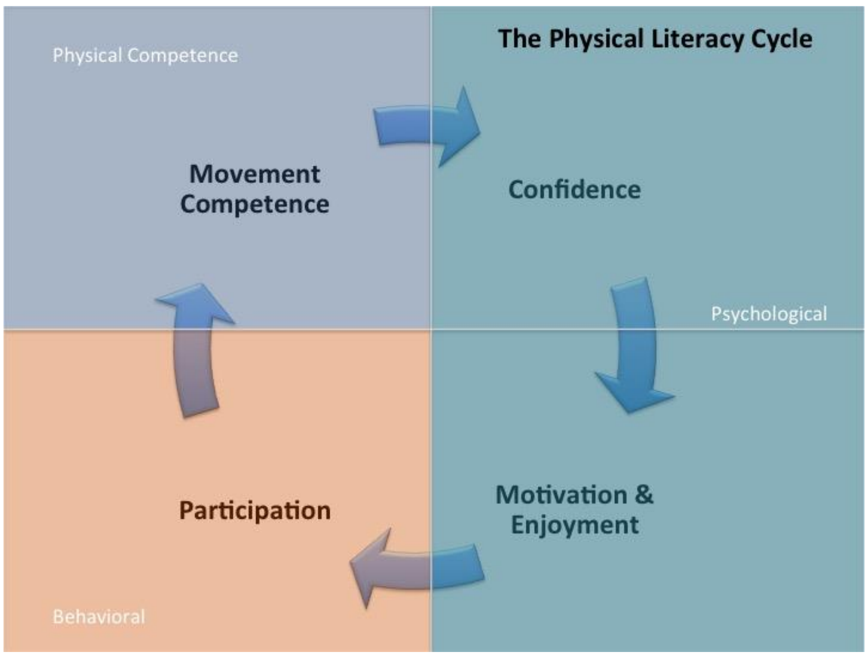

Figure 1 Physical Literacy Cycle. Modified from Taplin 2013. The physical literacy cycle highlights the connection between physical competence and the affective domain (confidence/motivation/enjoyment) leading to participation using the three sub-domains of physical literacy expressed in the Canadian consensus statement.

Interestingly, even in "pure" motor competence research, a recent meta-analysis examining the correlates of motor competence, pointed out a major deficit in the research in that there has been an absence of measurement of psychological parameters in association with physical competence measures (Barnett, Lai et al. 2016). In order to further develop the construct of physical literacy, it is essential to explore both physical competence and the psychological (affective and cognitive) domains as stipulated in all the definitions.

Conceptual Framework for Physical Literacy

In order to evaluate physical literacy, a guiding conceptual framework was developed in our laboratory (See Figure 2). This conceptual framework is consistent with the various definitions of physical literacy, and is although the framework was conceived prior to the Canadian Consensus statement on physical literacy, it is consistent with it. The research study presented herein adopts this physical literacy framework. In this simple conceptual framework, the combination of physical and psychological parameters leads to the ability to actively participate in society (distinct from being physically active), and therefore consistent with the Physical Literacy Cycle proposed by Taplin. The physical componentry includes motor competence expressed in a diverse movement skill set expressed in numerous physical and social environments. The term movement vocabulary expresses the number of skills/tasks that the person is competent at performing in all environments (land, air, ice, snow, water). The term, movement vocabulary embodies the concept of a journey, where an individual's diversity of movement competence grows and adapts through the lifespan. The key elements on the psychological side are confidence, motivation and enjoyment. The combination of the physical and psychological components contributes to active participation in recreation, sport, vocation and activities of daily living. The term active participation is distinct from the simple measures of physical activity, as it includes the importance social participation. Through continued and consistent active participation individuals would accrue mental, social and physical fitness and well-being. The inter-relationships (associations) between the componentry of the framework will be explored in this study.

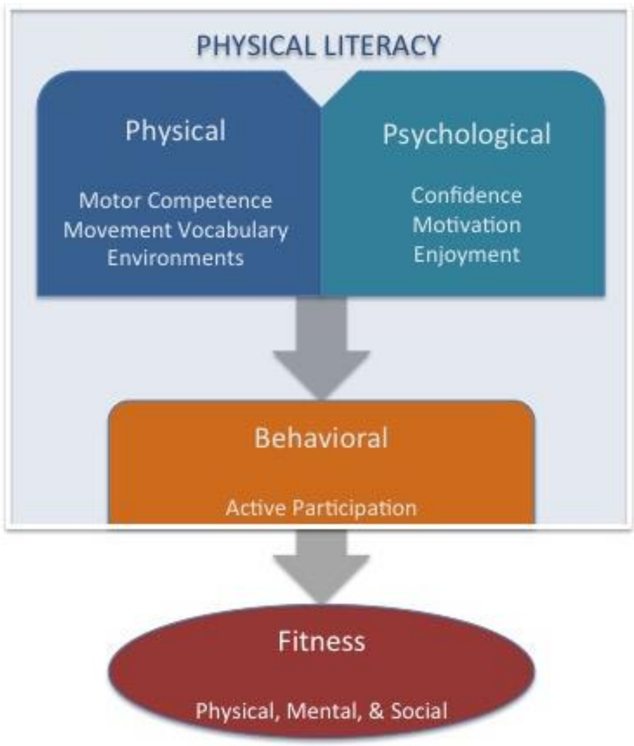

Figure 2. Physical literacy conceptual framework. Physically literate individuals have competence in a wide variety of movement skills in various settings (movement vocabulary) and have the confidence and motivation to participate actively in society, which provides them enjoyment. The outcome of consistent active participation are physical, mental and social well-being (overall fitness).

Physical Literacy and Movement Competence

Physical literacy advocates believe that having competence in a diverse movement repertoire in multiple environments provides the platform upon which engagement in physical activities can take place – in other words – the opportunity to participate in physical activities is opened with movement skill competence. This belief is supported by findings in related fundamental movement skill (FMS) studies, where childhood proficiency in FMS have been found to explain up to 12% of the variance in self-reported physical activity of adolescents (Barnett, van Beurden et al. 2009). Cohen and colleagues (Cohen, Morgan et al. 2014) reported correlations ranging 0.1 to 0.22 ($p<0.01$) using locomotor and object control competence to predict the duration of moderate to vigorous phsyical activity in children. While this positive link is weak, most of the tools (Cools, Martelaer et al. 2009) for the assessment of FMS, exhibit various limitations (Cools, Martelaer et al. 2009) such as ceiling effects and do not have the capacity to detect motor differences over a broad range of ages (See List below). All of these FMS assessments (Simons, Daly et al. 2008, Cools, Martelaer et al. 2009) were designed to detect deficits in movement skills, and use criterion based checklists to assess the presence of entry level features of the movements such as throwing, hopping, running and leaping. An additional limitation is that FMS are comprised of a basic level of movement and does not comprise an assessment of functional ability which would include spatial awareness, sequencing, selection, and confident execution of movement relative to or in response to the environment or setting (physical or social). As such, they are designed to detect deficiencies in motor competence rather than ability. So, in a way it is unsurprising that the correlations of competence assessed by these FMS tools to physical activity are relatively low. Perhaps tools that assess "functional" motor competence would exhibit stronger correlations to PA, a tool which does not have ceiling effects, and that assesses the range of motor competence from disability to entry level competence to expert mastery or proficiency.

Pre-school tests (ages 0-4):

  - Peabody Developmental Motor Scales – 2nd Edition (PDMS-2) (for age 0-4)
  - Movement Assessment Battery of Children (M-ABC) (for age 4)
  - Bruininks-Oseretsky Test of Motor Proficiency 2 (BOT2) (for age 4)
  - Test of Gross Motor Deficiency 2 (TGMD2) (for age 3-4)
- Tests for children (for age 5-12):
  - PDMS-2 (for age 5-6)
  - M-ABC (for age 5-12)
  - BOT2 (for age 5-12)
  - TGMD2 (for age 5-10)
  - KörperKoördinations Test für Kinder (KTK) (for age 5-12)
- Tests for adolescents (ages 13+):
  - KTK (age 13-14)
  - BOT2 (age 13-21)

In spite of the limitations to the motor competence assessment tools, other research supporting motor competence as a keystone component that may foster physical activity (Cohen, Morgan et al. 2014) includes the reports of sex differences between adolescent boys and girls in motor competence particularly object control (Cliff, Okely et al. 2009, Barnett, van Beurden et al. 2010). It is well demonstrated that boys of this age are more physically active than girls (Trost, Pate et al. 2002, Sherar, Esliger et al. 2007), so is it possible that differences in movement competence or perhaps physical literacy contribute to this difference in physical activity? Motor competence differences have been found for different obesity categories in adolescence (Cliff, Okely et al. 2012, Cattuzzo, dos Santos Henrique et al. 2016, O' Brien, Belton et al. 2016). In a motor competence interventional trial, overall motor competency and locomotor improvements have been found to weakly mediate the improvement in both physical activity and cardiovascular fitness (Cohen, Morgan et al. 2015).

While FMS research findings provide partial support for physical literacy (Lubans, Morgan et al. 2010, Cohen, Morgan et al. 2014, Cohen, Morgan et al. 2015), studies need to be performed which combine both physical and psychological measures tied to health related fitness, performance and physical activity outcomes (Barnett, Lai et al. 2016).

Assessment of Physical Literacy

In Canada, a number of physical literacy assessments have been developed; PLAY tools by the University of Manitoba were developed in 2009 and released by Canadian Sport for Life in 2012 (Sport for Life 2014), the Passport for Life tool was developed by PHE Canada (Physical and Health Education Canada 2013) and the Canadian Assessment of Physical Literacy (CAPL) (Healthy Active Living and Obesity Research Group 2014) from the Healthy Active Living and Obesity Research Group (HALO). The PLAY tools were designed as research and program evaluation tools, while the Passport for Life tool was designed for formative assessment in education, and CAPL was primarily designed as a population surveillance tool.

Physical Literacy Assessment of Youth (PLAY)

The PLAY tools are a suite of assessments (Sport for Life 2014) that were developed using the COSMIN checklist for health instruments (Mokkink, Terwee et al. 2010) and is consistent with model of the PL domains identified in the Canadian Physical Literacy Consensus Statement. The current suite of tools includes PLAY Fun; an assessment of motor competence, confidence and comprehension; PLAY Self; a self-assessment tool; PLAY Parent – a parental surrogate assessment of the child; PLAY Coach; a surrogate assessment of the child by the coach or PE teacher; PLAY Inventory – a child's self-report of participation in activity. The play tool suite is open source with the recording sheets and workbooks available online (Sport for Life 2014). The suite of tools is suitable for use with ages 7 and above.

The physical competence domain is assessed using the PLAY Fun tool which assesses movement competence in 18 land based movement tasks that are curriculum linked, as well as the confidence and comprehension to execute the selected movement task. The motor competence assessment in PLAY Fun uses a holistic rubric with a 100 mm visual analog scale that has multiple anchors for rapid assessment. As an ability assessment tool, the holistic rubric therefore, is capable of assessing competency over a broad range of proficiencies (and theoretically has no ceiling effect). This makes it distinct from other motor development tools that assess disability by using criterion-based assessment. Further, the tool assesses tasks rather than skills so that it includes an evaluation of spatial awareness, skill sequencing and selection in the competency evaluation. The competency assessment for the scale for each movement has explicit schema that are used for categorization of the participant's movement competence. The schema are available for each of the 18 movements in the online workbook.

The psychological domain (affective and cognitive) of physical literacy is assessed using the PLAY Self tool. The PLAY Self tool has three sections; one assessing participation in various environments, one assessing the affective and cognitive domains, and one examining the valuing of literacies. Self-assessment of perceived movement competence, confidence and enjoyment among other constructs is assessed using a 13 item questionnaire.

The behavioural domain is assessed using PLAY Inventory which assesses active participation in society. The PLAY Inventory contains a list of 95 possible activities plus space to indicate other not listed activities.

As well, there are two physical literacy assessment tools (PLAY Parent and PLAY Coach) that were designed to provide surrogate assessments of physical literacy of children and youth. Based upon the PL conceptual framework, the PLAY Tools do not include physical activity, fitness or performance measures as they are viewed as outcomes of PL. Liz Taplin and the research team of John Cairney (Taplin 2013, Cairney 2016) have identified the PLAY tools as showing promise to assess the physical literacy construct identified in the IPLA definition. Further description of the PLAY tools is found in the Methods section of this document.

Canadian Assessment of Physical Literacy (CAPL)

The CAPL tool uses a comprehensive testing battery that assesses multiple domains including body composition that goes beyond those accepted in physical literacy definitions. The CAPL tool is targeted for a narrow range of children aged 8 to 12. The physical competence components of the CAPL tool includes movement competence but also assesses health related fitness and body composition measures. The CAPL tool includes an assessment of sedentary and moderate & vigorous physical activity time; a health knowledge category that includes knowledge of physical activity, sedentary and screen time guidelines; and a motivation and confidence category. Interestingly movement competence (score of an obstacle course) comprises only 8.6 percent of the total physical literacy score, while physical activity behaviours are accorded 21 percent of the physical literacy model. Recent physical literacy construct evaluation of the CAPL tool has revealed issues with the inclusion of body composition within the physical competence category with findings that the fitness score was the factor that loaded the most onto the physical competence factor (Longmuir, Boyer et al. 2015). A recent Delphi process to re-evaluate the CAPL model of physical literacy also recommended that the model be revised to represent the overlapping nature of the physical competence, motivation and knowledge domains (Francis, Longmuir et al. 2016). Consensus was not reached regarding the inclusion of a time element in the obstacle course in addition to the assessment of the motor skill. Other issues are due to the aggregate scoring system, where interpretation of the CAPL results may be misleading. A child may score high on the physical competence tests yet low on knowledge and understanding yet have the same aggregate score as a child with reverse findings (Corbin 2016). Further evaluation of the CAPL assessment tool is required.

Passport for Life

Passport for Life tool (Physical and Health Education Canada 2013) assesses four components of the physical education curriculum related to physical literacy: Active Participation, Living and Personal Skills, Fitness and Movement Skills. It was developed for use in the educational system as a formative assessment tool for generalist and physical education specialists to utilize, and was not intended summative assessments (report cards) or for research purposes. The Passport for Life tool uses a four point scale which were designed to a partially align with the PLAY tool movement competency anchors (emerging, developing, meeting expectations and accomplished). The Passport for Life tool has grade range specific versions (3 to 6, 7 to 9, and 10 to 12). The Passport for Life tool was designed to assess curricular components of the PHE curricula from across Canada, so it is not specifically designed to assess physical literacy per se. The active participation, the movement skill component and some of the personal and living skill components overlap with physical literacy domains. But the inclusion of fitness assessment component was due to curricular expectations, not as an assessment of physical literacy.

Physical Literacy Programs

Canada has been a worldwide leader in the development and adoption of the physical literacy concept. The early thought leaders of physical literacy development in Canada were Canadian Sport for Life, Sport Canada, and Physical and Health Education Canada (PHE), as well Canadian Parks and Recreation Association. Shortly after their adoption, numerous other agencies and institutions adopted the term including RBC, Hi

Five and ParticipACTION to name a few. In March of 2016, the Government of Canada's Standing Senate Committee on Social Affairs, Science and Technology, in its *Obesity in Canada: A Whole-of-Society Approach for a Healthier Canada* report (Ogilvie 2016) recommended adoption of ParticipACTION's proposal entitled *Active Canada 20/20: A Physical Activity Strategy & Change Agenda for Canada*. Included along with a number of other priorities, *Canada 20/20* recommends that educators, caregivers and coaches be trained in the principles of physical literacy stating that "*physical literacy opens the door to a world of opportunities in physical activity and sport. Through quality sport and physical activity experiences built on physical literacy principles, we can increase kids' skills as well as their confidence, competence and motivation to be active"* (Antunes 2016).

Even prior to the Senate's recent support of physical literacy, the physical literacy 'uprising' that has taken place over the past decade has spurred numerous programs in Canada such as 'Passport for Life' (Physical and Health Education Canada 2014), 'Run Jump Throw' (RJT) Program (Athletics Canada 2006), various recreation programs (Canadian Sport for Life and Canadian Parks and Recreation 2013), as well as the Long Term Athlete Development (LTAD) model (Canadian Sport for Life 2014) based upon the notion that physical literacy is the missing link for the development and maintenance of a physically active lifestyle (Higgs 2010, Keegan 2013). Worldwide, the physical literacy movement has led to other associations and programs adopting the concept, notably including organizations such as the Society of Health and Physical Educators of America (SHAPE America), the American Youth Circus Organization (AYCO), 'Project PLAY' of the Aspen Institute in the United States and Northern Ireland's 'Skills 4 Sport' program, the Physical

Literacy Framework and the Physical Literacy Programme for Schools (PLPS) in Wales, and Australia's Game Plan to Get Australia Moving (Keegan 2013).

Physical Literacy Educational Strategies in Physical Education

Physical education is one of the settings which contributes to the development of physical literacy. Physical education curricular objectives in Canada (PHE Canada 2014), the United States (SHAPE America) and the Wales (PLPS) have recently adopted physical literacy as an objective of physical education programming. Physical educators have identified that highly effective instructional strategies must be used to develop the domains of physical literacy (Roetert 2015). Effective instruction for the development of physical literacy in physical education requires time, practice, appropriate content adjustment for different levels of movement competence, individual or reciprocal practice, short focused instruction, and a variety of tasks to promote active engagement (Silverman 2015). Waiting in line ups to perform a task is to be avoided as it can negatively correlate to movement skill (Silverman 2015). Appropriate practice in skills and at the right level with feedback for each student is also necessary to foster greater achievement, and produces better achievement than a games like situation where the less skilled students do not have equal opportunities to practice as the higher skilled students (Silverman, Subramaniam et al. 1998, Silverman 1999, Silverman 2015). This approach is in contrast to the popular 'low organized games' approach of many physical education teachers who have the well-meaning intention of providing physical activity opportunities to their students.

The physical literacy approach in PE enables a shift in the relationship between learners and educators where a learner's individual interest and capability are respected and developed, and importantly, social comparisons are minimized. Additionally, the competitive sport model of instruction is also removed from the general physical education setting (Roetert 2015) and meaningful inclusive participation becomes the new focus (Roetert and Jefferies 2014). Physical literacy as an outcome of physical education should be achievable by all, not just a select few (Whitehead 2010).

The Run-Jump-Throw (RJT) Program was developed by Athletics Canada (Athletics Canada 2006) as a physical literacy enriched program for children, which implements the instructional design as described above. The RJT Program has been adopted by numerous schools as a foundational physical literacy program. Fundamental running, jumping and throwing movements are taught in a progressive sequential manner. Each lesson plan offers a variety of methods to develop a movement skill in a non-competitive manner. Movements are performed together in a parallel manner instead of from a line up so social inhibition is minimized. Students are encouraged to use imagery to think about the movement, how to perform it and are provided the opportunity to explore the movement in a non-prescriptive manner. Purposeful free play encourages learner creativity where self-imagination to solve problems facilitates ownership of the movement. This in turn fuels motivation to participation in the activity.

Physical Literacy Research Needed

To date, there has been only one physical literacy study available through a MSc thesis comparing a physical literacy program to regular physical education programming

(Kiez 2015). This study evaluated the efficacy of circus arts instruction, as a quality physical literacy experience, in physical education. Findings indicated that circus arts instruction in PE substantially increased physical competence in movement skills with an endpoint difference of almost 8% between the intervention and control schools. Additionally, a smaller gender gap in motor competence was found in the intervention arm compared to the regular PE group. The changes in motor competence were also associated with numerous other improvements in the psychological domain (eg. Confidence).

In the current context of the inactivity and obesity crisis facing Canada, plus the present investment into physical literacy programming, evidence demonstrating the value of said investment is urgently needed. Research is required that describes the physical literacy trajectory of children and youth using the key PL sub-domains (physical competence, affective & cognitive components of psychology, and behavioural) as described by the Physical Literacy Consensus Statement, and relates physical literacy to health related fitness measures including body composition, and to physical activity.

Finally, since considerable investment to embed physical literacy into Canada's physical education curriculum as well as into sport and recreation programming has already taken place, the efficacy of these initiatives need to be evaluated. An early adopter of the physical literacy concept was Athletics Canada with the Run-Jump-Throw program. This program delivers training on many of the key components in the locomotor and object control movement domains (Athletics Canada 2006) identified as important contributors to a youth's physical activity (Cohen, Morgan et al. 2014), as well as targeting the key motor competencies expected in the physical education curriculum (Manitoba Physical

Education/Health Education 2000). Evaluation of the RJT program's efficacy in developing physical literacy is needed.

Aims

The first aim was to describe physical literacy of children (grades 3 & 4) and youth (grades 8 & 12). The relationship and inter-relationship of the principle sub-domains of physical literacy (motor competence and psychological) with health related fitness, performance and physical activity measures will be explored.

Aim 1 Hypotheses

There will be grade dependent increases in motor competence.

There will be sex dependent differences in physical literacy (both physical and psychological) with male PL exceeding that of females.

There will be positive associations between motor competence and physical activity, cardiovascular fitness and sprint performance, and negative correlations to BMI and waist circumference (WC).

There will be positive associations between psychological sub-domain of physical literacy and physical activity, cardiovascular fitness and sprint performance, and negative correlations to BMI and WC.

There will be positive association between motor competence and psychological measures (PLAY Self, PSDQ, MPAM).

The second aim was to investigate the effects of the Run Jump Throw program embedded in physical education on the motor competence of children in grades 3 and 4.

Aim 2 Hypothesis

The Run Jump Throw enriched PE program will demonstrate significant improvement in motor competence over time, and have greater motor competence than comparison schools at endpoint.

Methods

Study Designs

Aim 1: To examine physical literacy in children and youth, cross-sectional evaluations were performed; one on children in grades 3 and 4, and then a second on youth in grades 8 and 12.

Aim 2: To examine the effect of the Run Jump Throw program embedded in physical education on the physical literacy of children in grades 3 and 4, a quasi-experimental design using matched comparison schools was employed.

Data Collection Timelines

The cross sectional data for grades 3 and 4 was collected in early 2010 while the grade 8 and 12 data was collected in the spring of 2012. The Run Jump Throw interventional study took place from January to April 2010. These studies were reviewed and approved in 2009 (Grade 3/4 and RJT Intervention) and 2012 (Grade 8/12) by the Health Research Ethics Board of the University of Manitoba (H2009:359 & H2012:077).

Sampling Frame

For the cross-sectional studies, grade 4 was selected as the primary population for assessment of children, and grade 8 as the primary population for youth. Grade 4 was targeted for a variety of reasons; 1) due to the fact that the Manitoba Health and PE curriculum document focuses on the development of fundamental movement skills at this grade, 2) at this age the differences between male and female motor competence begins to emerge (Barnett, Lai et al. 2016), 3) the children are not likely undergoing the pubescent growth, and 4) the differences in physical activity levels between sexes also appears at this age (Troiano, Berrigan et al. 2008). In Manitoba primary schools, there are numerous grade 3/4 split classes, so the sampling frame necessarily included grade 3 children as well. This also provided a convenient sample to differentiate physical literacy between grade 3 and 4 children.

Grade 8 was chosen for assessment of youth for the following reasons; 1) the majority of youth at this age will be on in the final stages of peak height velocity changes, 2) there is a dramatic reduction in physical activity levels after age 12 (Troiano, Berrigan et al. 2008), 3) males show significantly and substantially greater PA then females (Troiano, Berrigan et al. 2008), and 4) the delivery of the Manitoba Health and PE curriculum at this grade is dependent on the existence of entry level competence for the fundamental movement skills assessed. A sample of grade 12 students was also assessed as a convenient sample for illustration of the grade dependent changes in motor competence.

For the interventional study, grade 4 was selected as this is the middle of the target age range for the Run Jump Throw program (Athletics Canada 2006). Once again, due to the existence of the split classes in elementary schools, which include grade 3 and 4 students, the study also included children in grade 3.

Instruments

Table 1 outlines the instruments assessed for each grade for the cross-sectional evaluations. Each instrument is described below.

Table 1. Instruments used in the cross-sectional studies of the physical literacy of children and youth.

Instrument	Grade 3 & 4	Grade 8 & 12
PLAY Inventory	X	X
PLAY Fun	X	X
PLAY Self		X
Sprint Speed	X	X
CV Fitness		X
BMI	X	X
Waist circumference		X
Physical Self-Description Questionnaire		X
Motivation for PA Questionnaire		X
Accelerometer derived PA		X

Play Fun

The Physical Literacy Assessment of Youth – Fundamentals (PLAY Fun) was developed at the University of Manitoba in 2009-2010 and subsequently released to Canadian Sport for Life in 2012 for open source distribution (Sport for Life 2014). PLAY Fun assesses the motor competence for movement tasks that are linked to the movement skills strand of the Manitoba Heath and Physical Education Curriculum (See Table 2 below), as well as the confidence to perform each task, and indicators of the comprehension of movement terminology associated with each task. For the purposes of this thesis only the motor competence scores were utilized.

Motor Competence Assessment: PLAY Fun uses a visual analog scale to assess motor competence for each movement task modified to employ multiple "anchors" for rapid assessment (See Figure 3 below). A score of zero refers to the inability to perform the task, and a score of 100 would correspond to expert proficiency, **independent of age**. The scale is separated into two major categories; Developing (0-49 mm) and Acquired (50-100 mm). The Developing category is further subdivided into two sub-categories, Initial and Emerging. The Acquired category is also subdivided into Competent and Proficient. The four competency sub-categories are distributed equally across the 100 mm scale: Initial (0-24), Emerging (25-49), Competent (50-74) and Proficient (75-100). By design, a score over 50 will reflect that the participant has entry-level competence for the movement skill assessed.

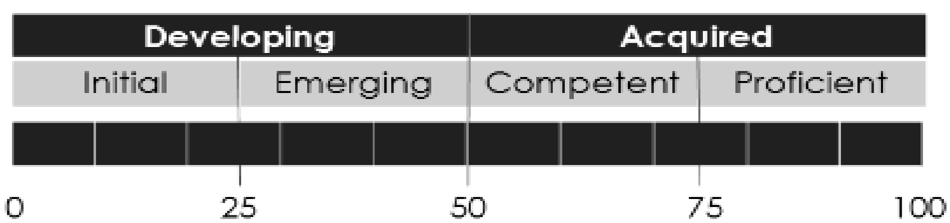

Figure 3 PLAY Fun Scale.
The PLAY Fun motor competence scale is a 100 mm visual analog scale (numbers are not included on the actual scale). For each movement task, the assessor places a tick along a 100 mm line using the categorical anchors as guides.

A holistic rubric assessment methodology is employed with a fixed assessment schema for each movement task. The assessment rubrics provide holistic exemplars for each sub-category for each of the 18 movement tasks. The assessor does not use specific criterion for achievement of each category. A complete list of rubrics is available online

(Canadian Sport for Life 2014). The holistic rubric (schema) for assessment is shown below for the Hop (Table 2).

Table 2 PLAY Fun: Holistic rubric example for a hop.

Verbal instructions are as follows: *"I want you to hop from this pylon to the next. I want you to hop as best you can. Please hop from here to there. Ready? Hop now."*

Developing	Acquired
Initial: Presence of numerous major gaps during execution: • Fails to maintain single leg support and touches down opposite foot • Performs a jumping action • Upper body and lower body in asynchrony	Competent: Basic level of execution with minor sequencing errors: • Able to hop on one leg from start to end with medium distance hops • Evident aerial phase • May not employ opposite leg to assist • Distance may vary from hop to hop in mid-range • Start and stop control may be limited
Emerging: Limited number of major gaps, but able to execute basic sequencing of the task: • Inconsistent distances and low amplitude of displacement (horizontal or vertical) • Balance control problems evident during progression • Starting is stutter-like • Stopping is sloppy and possibly over-hopping or premature ending	Proficient: Overall proficiency is depicted by the quality of the movement: • Substantial hopping distance that is consistent in distance in mid-range • Immediate transition to hopping and immediate hop to stationary position at end • Continuity in motion • Good horizontal and/or vertical speed • Uses opposite lower limb and upper body in synchrony with the other lower limb

Play Fun and Movement Skills Curricular Expectations

The Manitoba Health and Physical Education Curricula objectives outline the movement skill expectations for all grades (Manitoba Physical Education/Health Education 2000). The curriculum explicitly states that the student shall be expected to demonstrate entry level competence (basic form based features of the movement) for specific movement skills for each grade. Table 2 indicates the movement skill/tasks used in PLAY Fun which were matched to the curricular expectations for grade 4 and 5. So, children in grade 4 are expected to achieve an acquired status (score of 50 or greater on the PLAY Fun scale) for 16 of the 18 movement skills. By grade 5, children are expected to achieve greater than 50 for all 18 movement skills. In other words, a child in grade 4 should have a movement vocabulary (greater than entry level competency for 16 tasks), and the movement vocabulary should increase to 18 by grade 5.

Table 3 PLAY Fun and Manitoba Physical Education Curricular Expectations for Movement Skills.

Play Fun -movement skill/task	Grade 4 PE	Grade 5 PE
Run a square	✓	
Run there and back	✓	
Run, jump, land on 2 feet	✓	
Crossovers	✓	
Skip	✓	
Gallop	✓	
Hop	✓	
Jump	✓	
Overhand throw	✓	
Strike with stick	✓	
One-handed catch	Catching	✓
Hand dribble stationary & moving forward	Stationary	✓
Kick ball	✓	
Foot dribble moving forward	✓	
Balance walk (heel to toe) forward	✓	
Balance walk backward	✓	
Drop to ground & back up	✓	
Lift and lower	✓	

A checkmark indicates that a child is expected to demonstrate entry level competency in that grade.

Assessment: The PLAY Fun assessment was performed in the gymnasium by the trained assessors. Two assessors watched the children perform the tasks in sequence in groups of 2 to 4. One assessor managed the administration of the test and provided the standardized cues, as well as assessed one to two children. The other assessor assessed the remainder of the children. The physical education staff was utilized to manage the participants in one half of the gym while other children were assessed.

PLAY Fun scoring: The assessor places a tick along the 100 mm line for each of the 18 movement skills immediately after the skill is performed. Individual scores (0-100) for each movement task were determined by measuring the placement of the checkmark on the line using a ruler. The average motor competence score was derived from all 18 skills/tasks. The motor competence for major sub-categories of movement were also derived; locomotor, object control, and body control/balance. The *movement vocabulary* of the children and youth was determined as the total number of movement skills that were "acquired" (greater than 50).

PLAY Fun Assessor Training: The assessors (8 total) had university related degrees and extensive experience in movement related areas of practice. All were trained (4 hour workshop) to use the holistic assessment rubric for each movement task, and the assessors were required to obtain practical experience in implementation of the tool on children for each grade.

PLAY Fun Reliability and Validity: The PLAY Fun tool has undergone reliability and validity evaluation in the laboratory (unpublished) for the motor competence component with excellent test-retest reliability (r=0.92), and very good inter-rater reliability based ICC of 0.89 (two-way mixed, consistency, average-measures ICC). Convergent validity was assessed to be good to very good (r=0.67) by comparing the average motor competence score of PLAY Fun to TGMD-2 combined raw subset scores for locomotor and object control skills in grade 3/4 children.

PLAY Inventory

Self-reported participation in leisure activities was obtained using a PLAY Inventory. Common leisure activities are listed on a single sheet and using a checkmark the participant indicates if he/she took part in the activity within the previous year. Space is available to record other activities not included on the list. Total participation in activities was determined as a tally of the number of activity items. The total number of teams that a child participated in was tallied, and the number of lessons was also calculated.

Play Self

PLAY Self was developed in 2010 as a self-report of physical literacy. The PLAY Self tool was not ready for deployment for the first wave of cross-sectional assessment performed on grade 3 and 4 children. PLAY Self test-retest reliability is very high (r=0.94) in grades 4 to 6, and in youth (grade 8, 10 and 12) (unpublished). The convergent validity of PLAY Self will be assessed in this study by comparison to two tools; the Physical Self-Description Questionnaire and the Motivation for Physical Activity Measure. Play Self was designed to assess 1) participation in environments, 2) the affective/cognitive domains of physical literacy, and 3) the valuing of literacies.

PLAY Self scoring:

1. Engagement in six different environments (gym, water, ice, snow, outdoor and playground) was evaluated with a 4 point scale. The sum of the scores was used to represent environmental participation (max score of 24).
2. The physical literacy self-description section assesses the affective/cognitive domains using 13 questions (see below). All questions are scored on a four point Likert like scale. The sum of scores from all questions was used to represent the child's self-description of psychological domain of physical literacy. A total score for this section was computed (maximum =52).

    1. IT DOESN'T TAKE ME LONG TO LEARN NEW SKILLS OR SPORTS OR ACTIVITIES.
    2. I DON'T UNDERSTAND THE WORDS THAT COACHES AND PHYS-ED TEACHERS USE
    3. I THINK I HAVE ENOUGH SKILLS TO PARTICIPATE IN ALL THE SPORTS AND ACTIVITIES I WANT.
    4. I BELIEVE THAT BEING PHYSICALLY ACTIVE IS IMPORTANT FOR MY HEALTH AND WELL-BEING.
    5. I BELIEVE THAT BEING PHYSICALLY ACTIVE MAKES ME HAPPIER.
    6. I BELIEVE I CAN TAKE PART IN ANY SPORT/PHYSICAL ACTIVITY THAT I CHOOSE.
    7. MY BODY ALLOWS ME TO PARTICIPATE IN ANY ACTIVITY I CHOOSE,
    8. I WORRY ABOUT TRYING A NEW SPORT OR ACTIVITY.
    9. I WORRY ABOUT HAVING ENOUGH MONEY TO DO SPORTS OR ACTIVITIES THAT I LIKE.
    10. I AM CONFIDENT TO PERFORM ACTIVITIES.
    11. I CAN'T WAIT TO TRY NEW ACTIVITIES OR SPORTS.
    12. I AM USUALLY THE BEST AT DOING ACTIVITY IN CLASS.
    13. I DON'T REALLY NEED TO PRACTICE MY SKILLS, I'M NATURALLY GOOD.

3. The last section assesses the self-rated importance of three different types of skill based literacies (read/write, math, movement) in three settings (at school, at home and with friends). The valuing literacies section is scored as using a 4 point Likert like scale.

Physical Self Description Questionnaire

The Physical Self Description Questionnaire (PSDQ) (Marsh 1996, Marsh 1997) is a 70-item scale designed to measure physical self-concept, specifically perceived physical fitness and competence, and general self-esteem. The PSDQ was developed in Australia and has good test–retest reliability and internal consistency (Marsh 1996, Marsh 1997, Schipke and Freund 2012). It also has evidence supporting construct, cross-cultural, convergent and discriminant validity (Marsh, Marco et al. 2002). It is designed for use with adolescents. The PSDQ contains 70 items across 11 subscales of physical self-concept including Strength, Body Fat, Physical Activity, Endurance/Fitness, Sport Competence, Coordination, Health, Appearance, Flexibility, General Physical Self-Concept, and Self-Esteem. Each subscale contains 6 items, except for Health and Self-Esteem which contain 8 items each. The PSDQ takes 20 minutes to complete and can be administered in small groups. The PSDQ is marked using a six-point Likert scale from one (false) to six (true). Scores are tallied to give a total score for each factor, with higher scores indicating greater levels of self-concept.

The PDSQ will be used to examine the relationship between physical self-concept and physical activity, and motor competence (PLAY Fun), and allow for an assessment of convergent validity for PLAY Self.

Motivation for Physical Activity

The Motives for Physical Activities Measure –Revised (MPAM) (Ryan and Deci 2000), assesses degree of intrinsic or extrinsic motivation to physical activity (Ryan, Frederick et al. 1997). The importance of the following five motives for engaging in physical activity; appearance, social, competence, fitness, and interest/enjoyment are rated (Ryan, Frederick et al. 1997). Competence and interest/enjoyment are considered to be intrinsic motivators, while social, appearance and fitness are extrinsic motivators. Excellent reliability and internal consistency of the MPAM has been demonstrated, with Cronbach Alpha values of >0.89 for each subscale (Woods, 2007). The MPAM also has fair to good construct validity to the perspective of Self-Determination Theory (Wilson, Rodgers et al. 2002).

The MPAM will be used to examine the relationship between motivation and physical activity, and motor competence (PLAY Fun), and provide partial convergent validation examination for PLAY Self.

Body Composition

Height (m) was measured using a standard tape measure affixed to the wall. Body mass (kg) was measured using a Tanita BWB 800S (Tokyo, Japan) digital scale, and BMI derived. Waist circumference (cm) was measured using a standard cloth tape measure at the narrowest part of the waist between the lowest rib and the iliac crest (CSEP 2010).

Sprint Performance

Sprint speed was assessed using an opto-electric timing system (Brower Timing System, Draper, UT, USA) over developmentally suitable distances; 10 m for grade 3 and 4, and 15 m for grade 8 and 12. The running distance was measured by a Digi-roller (Calculated Industries DigiRoller Plus II 6425 Distance Measuring Wheel, Carson City, NV, USA). Start and finish lines were taped on the gymnasium floor and marked with pylons. Opto-electronic gates were set at the start and the finish lines. Each participant was instructed to run as fast as they can from a standing start. The participants were instructed to run "through" the finish line, and not "to" the finish line. Participants initiated the sprint on their own time using the same starting technique to improve accuracy (Young, Russell et al. 2008). Sprint time was recorded to 0.01 of a second. The sprint speed (m/s) was calculated.

Cardiovascular Fitness

Cardiovascular fitness was evaluated using the 20m Shuttle Run Test (20mSRT) (Leger, Mercier et al. 1988). The 20m SRT test was administered to participants over the age of 12. In the 20mSRT, subjects run back and forth on a 20 m course (a shuttle) and must touch the 20m line at the same time a sound signal is emitted from a pre-recorded audio. The speed of running is increased by 0.5 km/hr each minute by providing a shorter time interval between beeps. When the participant can no longer keep the pace, the total number shuttles and the last stage completed were recorded. This test has been found to be a reliable measure in both children (r=0.89) and in adults (r=0.95) (Tomkinson, Leger et al. 2003).

Physical Activity

Physical activity was objectively measured using the GT3X tri-axial accelerometer (Actigraph, Florida) which was worn on a belt strapped around the waist and the unit positioned above the right hip. Participants were instructed to wear the device for 7 consecutive days. The accelerometer was donned in the morning of the first day and then was collected on the eighth day, allowing for a maximum of 6.5 days of full day wear duration. Participants were instructed to remove the device for sleep, and washing and activities such as swimming. In some cases, the device was viewed as a hazard to sport participation (eg. volleyball) and was removed per the sport requirement.

Physical activity data was collected at a sampling rate of 30 Hz, with summed acceleration (activity counts) recorded at 1-second epochs and was converted to 10 second epochs for analysis. Standardized cut points were used to identify sedentary, low, moderate and intense activity levels for children using the Trost equation supplied in the Actigraph software (Version 5.6.1) (Pulsford, Cortina-Borja et al. 2011, Trost, Loprinzi et al. 2011). To identify non-wear time a zero count duration of 60 minutes was used (Colley, Gorber et al. 2010, Steele, van Sluijs et al. 2010, Colley, Garriguet et al. 2011). For data in a given day to be considered eligible for inclusion in statistical analyses, wear time in that day had to exceed 8 hours.

The mean daily values for minutes of moderate to vigorous physical activity (MVPA) and daily step counts were calculated.

Run Jump Throw Intervention in Physical Education

Design and Selection

A quasi-experimental design with matched comparison was employed for the Run Jump Throw (RJT) interventional study in children in grades 3 and 4. This design was selected as it holds very good external validity and excellent ecological validity. The use of matched comparison schools helped to mitigate other biases inherent in quasi-experimental designs. The interventional arm (RJT-PE) consisted of four schools while the comparison arm (PE) consisted of four schools. RJT-PE schools were selected based upon interest by the physical education teacher in the RJT program. Comparison schools were recruited after the RJT schools to provide a balanced comparison based upon geographical (rural, urban and sub-urban) and social-economic (SES) characteristics. The socio-economic factor index (SEFI) which considers income, education, employment and family structure was used as the SES indicator (Chateau, Metge et al. 2012). Table 4 outlines the basic characteristics of the schools.

Table 4 Characteristics of the RJT-PE and PE schools.

Group	Location	Type	Teacher	N	SEFI
RJT-PE					
1	Sub-urban	Public	PE SPEC	40	Low
2	Rural	Public	GEN	24	Low
3	Urban	Private	PE SPEC	25	Low
4	Sub-urban	Private	PE SPEC	36	Middle
PE					
1	Sub-urban	Public	PE SPEC	17	Low
2	Urban	Public	PE SPEC	28	Low
3	Rural	Public	GEN	22	Low
4	Sub-urban	Public	PE SPEC	10	Middle

PE SPEC = physical education specialist, GEN = general teacher

The comparison schools delivered the regular PE curriculum using the regular PE teacher. The comparison schools were only measured at the end point so as not to bias the PE teacher's delivery in the control schools toward the assessment tools outcomes which are curricular linked.

In order to account for the lack of a baseline measure in the comparison schools, a baseline measure was imputed from a study which employed the PLAY Fun tool in an PE intervention over similar time frame on grade 4 and 5 children (Kiez 2015). Imputation of the baseline, would allow us to partially account for any baseline differences in motor competence between the groups.

RJT Program

The RJT program was administered in the regular PE session by one of four trained RJT instructors over an eight-week period. Each instructor was assigned to a particular school where they provided RJT programing for the duration of the study. The regular PE teacher assisted in the delivery of RJT program. A 6 day school cycle is employed in Manitoba, so given an average of 4 PE classes per week, about 3 of the classes were devoted to RJT in the interventional arms. The RJT curriculum was delivered in over 32 classes in an 8 week period. PE class duration varied from 30 to 50 minutes depending on the school. The measurement time frame was 10 weeks, where the week prior to commencement of the RJT program was used for assessment of baseline, and the week after the completion fop the program was used for assessment of endpoint.

The RJT program contains base skills of running, jumping and throwing which are delivered in developmentally appropriate sequences. Lessons are progressive and cumulative starting from a fundamental movement pattern to the advanced execution of the task. An instructional kit is provided which includes hard copy format of the progressive lesson plans and a bag with some basic equipment (most of which was already available in schools). RJT was developed by highly regarded experts from Sport Canada's Long Term Athlete Development group as a foundational program for youth aged 7 to 12 in the delivery of physical literacy, and therefore suitably matched to curricular expectations in grades 3 to 6. RJT movement skill developmental lesson plans have very similar goals to that of the Manitoba Health and Physical Education curriculum movement skills framework.

The basic lesson plan outline was

1. a group discussion and visualization exercise,
2. warm-up,
3. skill drills,
4. participatory task/game, and
5. cool down/closure including reflection**.**

Statistical Analysis

Statistical analysis was performed using SPSS v 22. The alpha level was set to 0.05 with a beta of 0.2. For the cross-sectional studies, Table 5 outlines the key dependent variables and statistical analysis performed. Unless otherwise indicated, two tailed tests were conservatively selected.

Table 5. The primary statistical method and dependent variable list for each assessment tool.

Category	Assessment	Dependent Variables	By Grade	M vs F	Other
Physical literacy: Physical Domain	PLAY Fun	Total Motor competence (MC) Sub domains: Object control Locomotor Balance Movement vocabulary	By Grade 3,4,8,12 ANOVA – Post Hoc Test: Tukey's HSD Chi-Squared test	Independent t-test	Linear regression
Physical literacy: Psychological Domain	PLAY Self PSDQ MPAM	Total PLAY Self score Sub domain scores: Environmental Self-description Valuing literacies Total PDSQ Score Total MPAM Score	Grade 8 vs 12 Independent t-test	Independent t-test	Pearson correlation to MC, PDSQ and MPAM (and item scores)
Physical literacy: Behavioral Domain	PLAY Inventory	# activities # teams	Chi-Squared test		Pearson correlation to MC
Body Composition	Height & body mass Waist circumference	BMI (kg/m^{2}) Circumference (cm)	ANOVA – Post Hoc test: Tukey's HSD	Independent t-test	Pearson correlation to MC
Performance	Sprint test	Sprint speed (m/s)			Pearson correlation to MC, (bivariate and partial)
CV Fitness	20 m Shuttle Run	# laps			Pearson correlation to MC
Physical Activity	Accelerometry	Steps per day MVPA		Independent t-test	Pearson correlation to MC

M=male, F=female

Meaningful Interpretation: In order to create "meaningful" interpretations of the statistically significant correlations observed, the means for each dependent variable were computed for "binned" average motor competence based upon the 4 categories of competency (<25,25-49.9, 50-74.9, 75+) used in PLAY Fun. This would then permit estimations of the change in the dependent variables corresponding to a change in competency category, in particular from emerging (25-49.9) to competent (50-75). Although correlation is simply association not causal, the estimation of improvement with a change in motor competence is useful to interpret the potential meaning of the association observed.

Multiple Comparisons: A number of correlations were performed between motor competence and other variables, and since the occurrence of a type 1 error increases with each number of correlations performed, it is possible that some significant correlations may be spurious.

For the RJT interventional study, a mixed model (within and between) ANOVA was performed on motor competence using the imputed baseline with post-hoc tests (Tukey's HSD) when indicated.

Sample Size

Correlation: In correlation, the sample size determines the minimum statistically significant correlation coefficient that likely can be detected (differing from zero). For detection of correlation coefficients of 0.3 a sample size of approximately 85 is required, for 0.4 a sample of 47, and 0.5 a sample of 29. A priori, given and alpha of 0.05 and beta of 0.2, the study was designed to be powered to be able to detect correlation coefficients down to 0.3 for the grade 3/4 and for the grade 8 /12 groups. With the entire data set (n=299), grades 3 to 12, correlation coefficients down to 0.2 could be detected.

T tests and ANOVA: Motor competence was the key outcome used in the thesis, and this dependent variable was used to adequately power the study to detect differences. The variance (SD) of the motor competence was derived from the reliability studies performed (unpublished) on grade 4 and 5 children. We very conservatively estimated a difference between males and females of 2%, a difference between grades 3 and 4 of 3%, and a difference between groups in the RJT intervention of 3% based upon other studies of motor competence. Using a conservative estimate of variance (5) and differences expected, a sample size of 99, 44 and 44 per group are required to achieve adequate power to detect for grade, sex and between groups differences, respectively. Our sampling frame, provided adequate power to detect differences in our primary outcome.

Regression: A post hoc regression was employed to predict motor competence with 3 independent variables (BMI, sex and age). With low effect size (0.15), and an alpha = 0.05, a sample of 76 is sufficient. For this regression, the minimum sample size for adequate power was exceeded.

Results

The results are presented in two sections. The first section provides the results of the cross-sectional studies describing physical literacy of children and youth. The first section is separated based upon two main domains of physical literacy; 1) motor competence and 2) psychological. The second section reports on the Run Jump Throw interventional study.

Section 1: Physical literacy of children and youth

Participant Characteristics

The total sample size was 299 that included 170 males and 129 females from grades 3, 4, 8 and 12. The participant characteristics are described in Table 6. Using Cole's BMI cut-offs (Cole, Flegal et al. 2007), 29.9% of was classified as overweight or obese (OW/OB). There was a greater percentage of OW/OB in youth in early school ages (grades 3 and 4 - 33.0%) than in middle and high school ages (grades 8 and 12 - 22.4%). The average waist circumference was 79.0 cm (SD=12.38, min 59 and max 119) for the grade 8 and 12 youth. The average waist circumference for grade 8 males was 76.53 cm (10.51); 78.16 cm (11.17) for grade 8 females; 87.50 cm (12.6) for grade 12 males; 84.97 cm (19.04) for grade 12 females. For the grade 8 and 12 youth, there were 83 right-handed participants (84.7%) and 15 left-handed (15.3%).

Table 6 Participant Characteristics.

		N	Age (yr)	Height (m)	Mass (kg)	BMI (kg/m^2)	BMI Range (kg/m^2)
Grade 3	**Total**	**51**	**8.85 (0.54)**	**1.35 (0.06)**	**36.16 (10.82)**	**19.54 (4.72)**	**13.62-35.61**
	Male	25	8.79 (0.44)	1.35 (0.06)	35.33 (9.88)	19.06 (4.29)	13.62-34.09
	Female	26	8.91 (0.62)	1.35 (0.06)	37.16 (11.77)	20.01 (5.15)	15.68-35.61
Grade 4	**Total**	**150**	**9.70 (0.34)**	**1.40 (0.07)**	**37.00 (10.03)**	**18.69 (3.94)**	**12.29-29.87**
	Male	87	9.71 (0.34)	1.40 (0.07)	37.56 (9.21)	19.04 (3.83)	14.46-29.87
	Female	63	9.69 (0.34)	1.40 (0.07)	36.24 (11.09)	18.20(4.08)	12.29-29.61
Grade 8	**Total**	**79**	**13.46 (0.50)**	**1.65 (0.07)**	**59.23 (13.81)**	**19.08 (4.58)**	**11.94-30.89**
	Male	48	13.42 (0.50)	1.67 (0.07)	57.72 (13.30)	17.89 (4.05)	11.94-30.89
	Female	31	13.52 (0.51)	1.63 (0.07)	61.56 (14.46)	20.92 (4.79)	13.79-29.96
Grade 12	**Total**	**19**	**17.32 (0.67)**	**1.74 (0.08)**	**77.97 (19.14)**	**22.29 (4.97)**	**15.39-33.85**
	Male	10	17.4 (0.52)	1.80 (0.03)	83.72 (16.48)	23.23 (4.38)	18.38-33.85
	Female	9	17.22 (0.83)	1.68 (0.05)	71.52 (20.75)	21.25 (5.64)	15.39-33.05
TOTAL		**299**					

Values are expressed as mean (standard deviation).

Motor Competence

Motor Competence and Grade

The average motor competence includes all 18 movement tasks assessed by PLAY Fun. The average motor competence increased with grade for both sexes (Figure 4). Table 7 illustrates the average motor competence and motor competence separated by movement category; locomotor, object control and balance. With sexes combined, there was a significant difference in motor competence between grade 3 and 4 (P<0.05), between grade 4 and 8 (P<0.05), and between grade 8 and 12 (P<0.05).

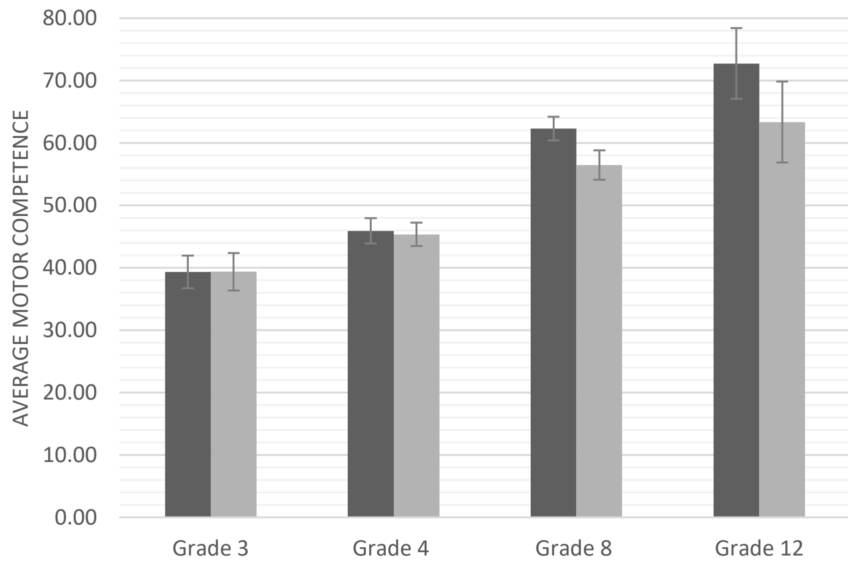

Figure 4 Average motor competence derived from PLAY Fun by grade and sex.
Dark shaded bars: males and lightly shaded bars: females. Error bars indicate 95% confidence intervals. G3 to G4 (P<0.05), G4 to G8 (P<0.05), G8 to G12 (P<0.05) both sexes combined.

Table 7 Average motor competence and sub-categories (locomotor, object control, and balance/body control) depicted by grade and by sex.

		GRADE 3			GRADE 4			GRADE 8			GRADE 12		
		N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Average	**Total**	**51**	**39.35**	**7.18**	**150**	**45.68**	**8.79**	**79**	**60.01**	**7.24**	**19**	**68.28**	**10.42**
	Males	*25*	*39.33*	*6.65*	*87*	*45.92*	*9.65*	*48*	*62.30*	*6.68*	*10*	*72.73*	*9.13*
	Females	*26*	*39.37*	*7.79*	*63*	*45.36*	*7.51*	*31*	*56.46*	*6.72*	*9*	*63.34*	*9.93*
Locomotor	**Total**	**51**	**37.17**	**8.25**	**150**	**43.56**	**9.92**	**79**	**59.74**	**7.24**	**19**	**63.91**	**9.49**
	Males	*25*	*36.10*	*7.19*	*87*	*42.59*	*10.46*	*48*	*61.35*	*6.93*	*10*	*65.99*	*9.67*
	Females	*26*	*38.20*	*9.18*	*63*	*44.88*	*9.03*	*31*	*57.26*	*7.12*	*9*	*61.61*	*9.27*
Object control	**Total**	**51**	**39.87**	**9.05**	**150**	**46.27**	**9.47**	**79**	**60.57**	**8.36**	**19**	**68.26**	**13.82**
	Males	*25*	*41.28*	*8.76*	*87*	*47.77*	*10.35*	*48*	*63.59*	*7.69*	*10*	*75.97*	*10.07*
	Females	*26*	*38.52*	*9.28*	*63*	*44.19*	*7.70*	*31*	*55.88*	*7.19*	*9*	*59.70*	*12.62*
Balance	**Total**	**51**	**47.84**	**9.27**	**150**	**52.87**	**12.94**	**79**	**59.62**	**11.87**	**19**	**79.32**	**9.64**
	Males	*25*	*45.37*	*10.10*	*87*	*51.49*	*13.83*	*48*	*62.38*	*11.81*	*10*	*80.85*	*9.55*
	Females	*26*	*50.22*	*7.87*	*63*	*54.76*	*11.44*	*31*	*55.35*	*10.80*	*9*	*77.61*	*10.01*

Differences between grades for each domain. Locomotor: G3 to G4 (P<0.05), G4 to G8 (P<0.05), G8 to G12 (P<0.05) both sexes combined. Object Control: G3 to G4 (P<0.05), G4 to G8 (P<0.05), G8 to G12 (P<0.05) both sexes combined. Balance: G3 to G4 (P<0.05), G4 to G8 (P<0.05), G8 to G12 (P<0.05) both sexes combined.

Table 8 shows the grade differences (absolute and grade normalized) in average motor competence and the three major sub-categories of movement skills. The largest mean differences in motor competence were found between grades 3 and 4 (Table 8), while the next largest mean difference was found between grades 4 and 8 (3.58 per year).

Table 8 Mean differences in motor competence between grades.
The absolute change in motor competence is shown along with the grade normalized difference in motor competence to adjust for years between grades.

	Mean Differences			
Grades	Average Competence	Locomotor	Object Control	Balance
Grade 3 to 4	6.33 (6.33)*	6.38 (6.38)*	6.39 (6.39)*	5.02 (5.02)*
Grade 4 to 8	14.32 (3.58)*	16.19 (4.05)*	14.3 (3.56)*	6.75 (1.69)*
Grade 8 to 12	8.27 (2.07)*	4.17 (1.04)*	7.7 (1.93)*	19.7 (4.93)*

**Significant differences between grades (P<0.05), ANOVA.*

Correlations between age of participants and motor competence and revealed significant correlations (average motor competence 0.702; locomotor 0.673; object control 0.653 and balance 0.479, all P<0.001).

Movement Vocabulary

As defined in the Methods section, the total number of "acquired" movement skills is termed the movement vocabulary. For grades 3 and 4 (Table 7), the average motor competence scores fell within the "emerging" category (25-49.9) of the PLAY Fun motor competence scale. Based upon the Manitoba PE & HE curriculum movement skills expectations, children by grade 4 are expected to have 16 of 18 movement skills acquired corresponding to entry level competence (a score greater and 50 on PLAY Fun scale). In grades 3 and 4 combined, there were only 2.5% of children that achieved the "acquired" status across 16 movement skills – this would represent their "movement vocabulary". In grade 8, 20 of 79 were meeting movement skill expectations established for grade 4/5! Males had a greater movement vocabulary than females ($P<0.05$).

Contingency tables were derived for the total number of movement skills with "acquired" or greater motor competence for frequency comparisons between grades 3 & 4, 4 and 8, and 8 and 12. A significant increase in frequency of acquired movement skills was observed from grade 3 to 4 (Chi-squared=14.4, $P<0.001$), 4 to 8 (Chi-squared of 87.5, $P<0.001$) but not 8 to 12. The sample size in grade 12 was small and the results are presented for illustration, so interpretation of this negative result requires caution.

Significant correlations ($P<0.05$) were observed between the number of "acquired" movement tasks and speed (r=0.58, includes all grades), and for grades 8 and 12 the following significant ($P<0.05$) correlations were observed; CV fitness (r=0.45), BMI (r=-0.44), waist circumference (r=-0.30), and total activities derived from PLAY inventory (r=0.28).

Motor Competence and Sex

Significant differences were found between males and females in average motor competence when combined across all grades ($P<0.01$), with males having greater competence than females. There were sex-dependent differences in average motor competence observed in grade 8 ($P<0.001$) and grade 12 ($P<0.05$). When examining sub-categories of motor competence (Figure 5 & Table 9), sex dependent differences emerged in grade 4 for object control tasks, and were significant across all movement sub-domains at grade 8. Sex based differences in object control widened from grade 3 to grade 8 to grade 12 (3.58 to 7.71 to 16.26 respectively).

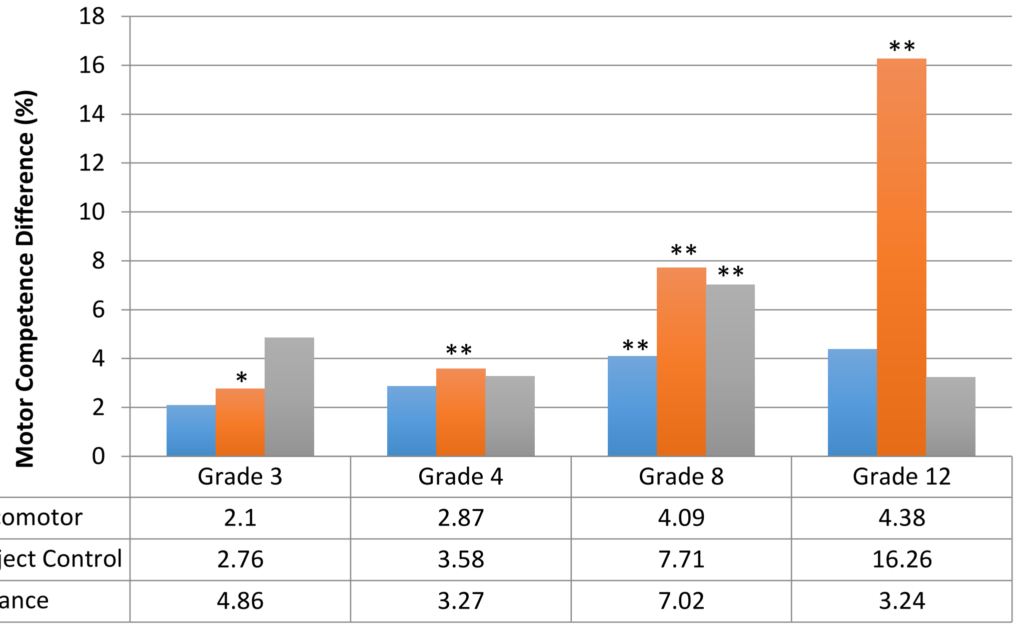

Figure 5. Sex dependent differences in motor competence for locomotor, object control and balance categories.

*Positive values indicate males>females. *Significant at P<0.05, **Significant at P<0.01*

Table 9 Motor competence of males and females.

Grade	N (M:F)	Motor competence		Locomotor		Object control		Balance	
		Male	Female	Male	Female	Male	Female	Male	Female
All	170:129	51.2 (13.0)	48.1 (10.4)	48.3 (13.7)	47.7 (11.5)	52.9 (13.6)	46.9 (10.8)	55.4 (15.2)	55.6 (12.2)
3	25:26	39.3 (6.7)	39.4 (7.8)	36.1 (7.2)	38.2 (9.2)	41.3 (8.8)	38.5 (9.3)	45.4 (10.1)	50.2 (7.9)
4	87:63	45.9 (9.7)	45.4 (7.5)	42.6 (10.5)	44.9 (9.0)	47.8 (10.3)	44.2 (7.7)	51.5 (13.8)	54.8 (11.4)
8	48:31	62.3 (6.7)	56.4 (6.7)	61.3 (6.9)	57.3 (7.1)	63.6 (7.7)	55.9 (7.2)	62.4 (11.8)	55.4 (10.8)
12	10:9	72.7 (9.1)	63.3 (9.9)	66.0 (9.7)	61.6 (9.3)	76.0 (10.1)	59.7 (12.6)	80.9 (9.6)	77.6 (10.0)

Shaded areas indicate significant differences between males and females. Dark shaded indicate P<0.01 and light shaded indicate P<0.05. Mean values (standard deviation).

Predicting Motor Competence with Age, Sex and BMI

Average motor competence was predicted employing age, sex and BMI (Table 10, P<0.001). This regression was performed given pre-existing studies that illustrate that a relationship between motor competence and these basic parameters should exist (Barnett, Lai et al. 2016).

Table 10 Regression of motor competence with age, sex and BMI.

Model	R	Adjusted R^2	Significance
FULL	0.73	0.52	<0.001

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
	21.784	3.157		6.901	<.001
AGE	3.552	.200	.723	17.732	<.001
SEX	-2.488	.977	-.103	-2.546	<.011
BMI	-.398	.112	-.146	-3.564	<.001

a. Dependent Variable: Average motor competence

Motor Competence and Hand Dominance

Hand dominance was obtained from Grade 8 and 12 participants. Eighty-two (84.5%) reported being right-handed and 15 (15.4%) reported being left-handed. Interestingly, left-handed participants demonstrated lower motor competence scores overall and for each of the sub-domains (Table 11).

Table 11 Motor competence and hand dominance.

Dominance	N	Average*	Locomotor*	Object Control*	Balance*
Right	85	62.25 (8.73)	61.02 (8.23)	62.87 (10.02)	64.33 (13.69)
Left	15	57.17 (5.26)	57.38 (4.01)	56.32 (7.19)	57.50 (13.51)

*Mean (standard deviation) values shown. * Indicates significant difference (P<0.05) between right and left hand dominance.*

Motor Competence and Health Related Fitness & Performance Measures

Motor Competence and Sprint Speed

Average motor competence had a positive correlation to sprint speed (r=0.86, P<0.001) (Figure 6) for all participants. Of course, this relationship would be partially confounded by simple growth and development so partial correlation was performed to control for age, as well as sex (See below). All motor competence domains exhibited similar correlations to sprint speed (Table 12) with a range of correlation coefficients from 0.59 to 0.86. Collapsed across ages, there was a sex specific difference (P<0.001) in speed, with boys running 0.4 m/s faster than girls. For grades 3 and 4, there was no significant difference observed in running speed between males and females. For grade 8 and 12 combined, a mean difference of 0.63 m/s in running speed was observed between males and females (P<0.001).

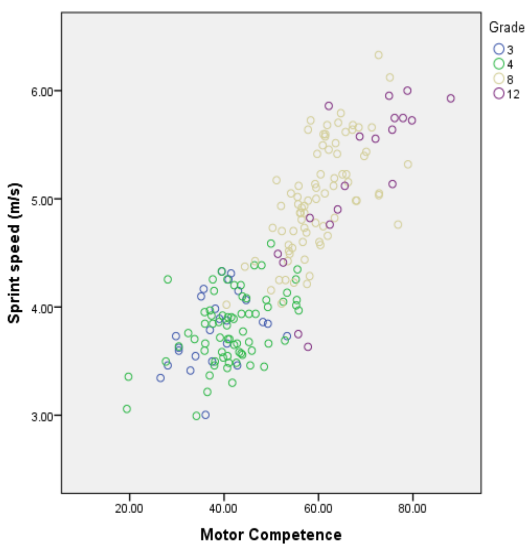

Figure 6 Scatterplot between motor competence and sprint speed

(Color coded by grade), r=0.86 overall, r=0.45 3&4, r=0.7 8&12, P<0.01

Table 12 Correlation between motor competence and sprint speed

	r
Average motor competence	0.86**
Locomotor	0.83**
Object Control	0.83**
Balance	0.59**

***Significant at P<0.01.*

After controlling for age and sex the significant relationship between motor competence and sprint speed remained (Table 13).

Table 13 Partial correlations between motor competence and sprint speed

	MOTOR COMPETENCE ENTIRE GROUP	MOTOR COMPETENCE GRADE 3 & 4	MOTOR COMPETENCE GRADE 8 & 12
SPRINT SPEED (M/S)	0.86**	0.43**	0.70**
CONTROLLING FOR SEX	0.85**	0.44**	0.64**
CONTROLLING FOR AGE	0.66**	0.45**	0.70**

***Significant at P<0.01.*

Motor Competence and Cardiovascular Fitness

The 20m Shuttle Run Test was administered to a subset of students in grade 8 in two different schools (N=35). A significant relationship was found between the number of shuttles and average motor competence (r=0.56, P<0.001) (Figure 7), as well as locomotor competence (r=0.56, P<0.001).

Males (n=17) had a significantly greater number of shuttles than females (n=18) with a mean difference of 22.03 shuttles (P<0.01) equivalent to just under a 2 stage difference in the Shuttle Test (6.94 (2.51) versus 4.69 (1.79)). The relationship between motor competence and shuttles was examined for each sex separately; a significant association was observed for males (r=0.48, P<0.001), and was approaching significance for females (r=0.41, P=0.09).

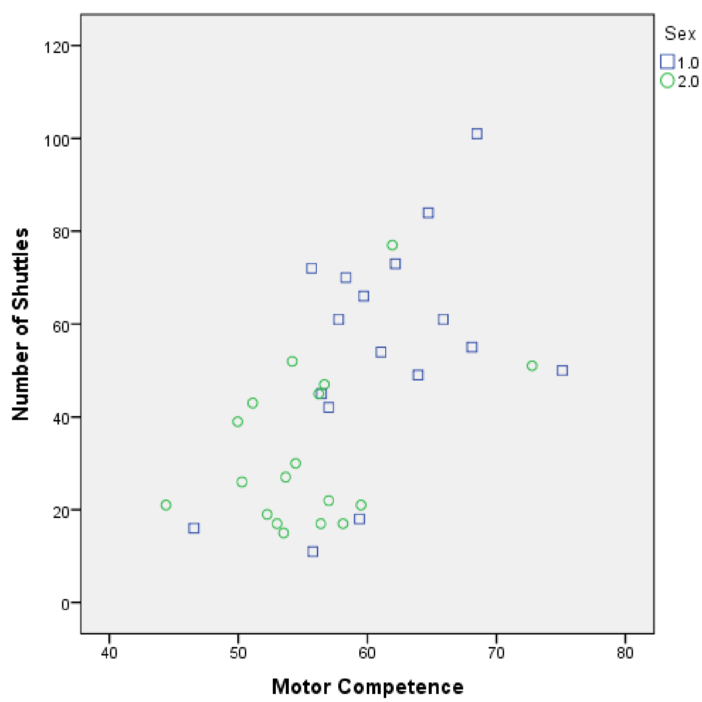

Figure 7. Relationship between motor competence and cardiovascular fitness
(Males: square symbol, Females: circle symbol) r=0.56, P<0.001

Motor Competence and Body Composition

Collapsed all grades, BMI was not correlated with average motor competence. However, when the children were separated using BMI into categories of overweight/obese (OW/OB) and normal weight, the average motor competence (54.73 (7.05)) for the OW/OB group was significantly lower ($P<0.05$) than the normal weight children (61.45 (6.65)). When analyzed by grade, there was no relationship between BMI and motor competence for grades 3 and 4 combined. However, there was a significant inverse association in grade 8 ($r= -0.48$, $P<0.001$) (Figure 8). Correspondingly for grade 8, there was a significant correlation between waist circumference and average motor competence ($r= -0.29$, $P<0.01$).

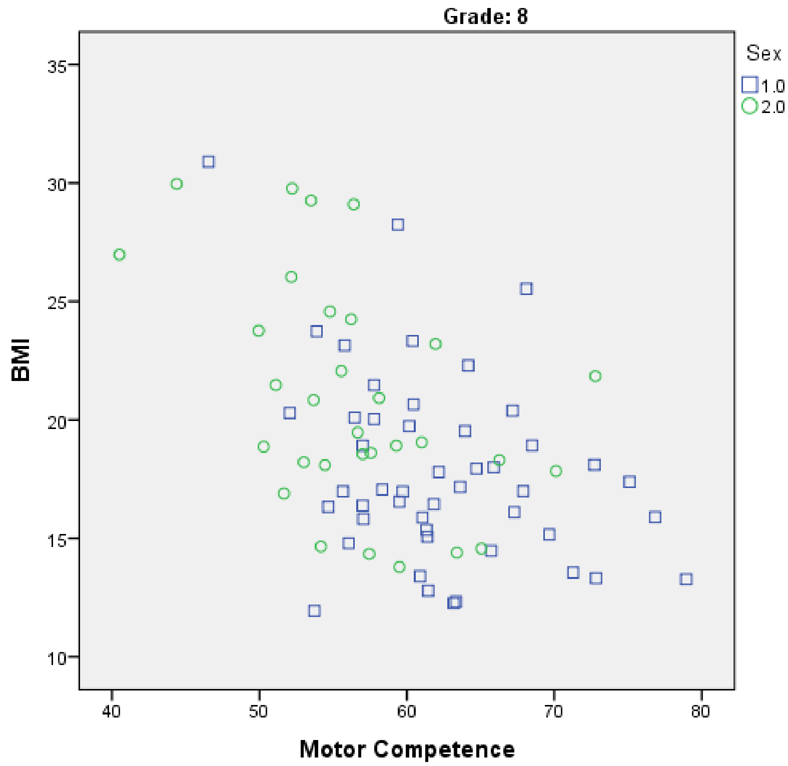

Figure 8 Relationship between BMI and overall motor competence
(Males: square symbol, Females: circle symbol), r= -0.48, P<0.001

Motor Competence and Physical Activity

Physical activity was assessed based upon a self-report of physical activity participation (PLAY Inventory) and an objective measure (accelerometry). Physical activity measures were examined in relation to physical literacy.

Motor Competence and Participation

Table 14 reports the correlations between self-reported participation (PLAY Inventory) and average motor competence. There were no sex differences detected between males and females, for overall participation, or participation on teams or the number of physical activity lessons.

Table 14 Active participation (PLAY Inventory) and correlation to average motor competence.

	N	Mean	SD	r
Grade 3, 4, 8 & 12 combined				
Total # of activities	142	23.05	11.23	0.17*
Number of team activities	90	1.66	1.76	0.39*
Number of lessons	85	1.6	1.97	0.35*
Grade 4				
Total # of activities	44	23.91	9.22	0.31*
Grade 8				
Total # of activities	79	24.05	12.38	0.23*
Number of team activities		1.45	1.66	0.25*
Number of lessons		1.34	1.84	0.16
Grade 12				
Total # of activities	19	18.85	10.06	0.34
Number of team activities		2.53	1.97	0.56*
Number of lessons		3.17	2.04	0.52

**Significant relationship (P<0.05) to motor competence.*

Motor Competence and Objectively Assessed Physical Activity

A summary of the objectively measured physical activity of the Grade 8 and 12 participants combined is provided in Table 15. There was no difference in daily steps or minutes of moderate & vigorous activity between Grade 8 and 12. However, there was a significant difference in daily steps and in duration of physical activity spent in moderate or vigorous activity between males and females (Table 16) with females having lower physical activity levels than males.

Table 15 Average physical activity levels of Grade 8 and 12 participants

	N	Mean	Minimum	Maximum	SD
Daily steps	97	6863	3242	10993	1766.9
MVPA (min)	97	23.36	4.96	43.75	8.60

Table 16 Physical activity levels of males and females

	Males N=57	Females N=40	Mean Difference
Daily steps	7121.9 (1749.5)	6493.5 (1746.8)	628.34*
MVPA (min)	24.79 (8.67)	21.31 (8.16)	3.48*

*Values are mean (SD). *Significant at P<0.05*

A significant correlation between motor competence and objectively assessed physical activity was observed for average daily step count (r=0.54, P<0.001, Figure 9) and the duration of moderate and vigorous physical activity (r=0.41 P<0.001, Figure 10).

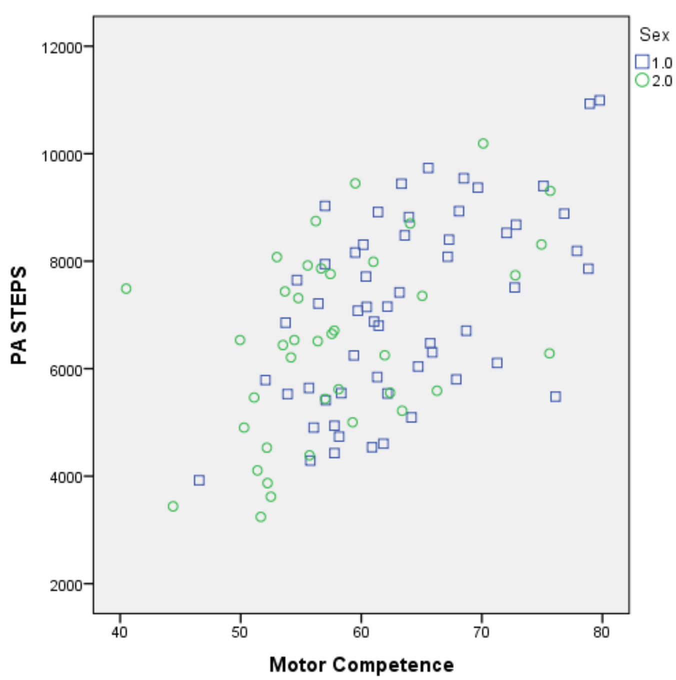

Figure 9. Relationship between average daily step count (PA STEPS) and average motor competence.

(r=0.54, P<0.001, Males: square symbols, Females: circle symbols)

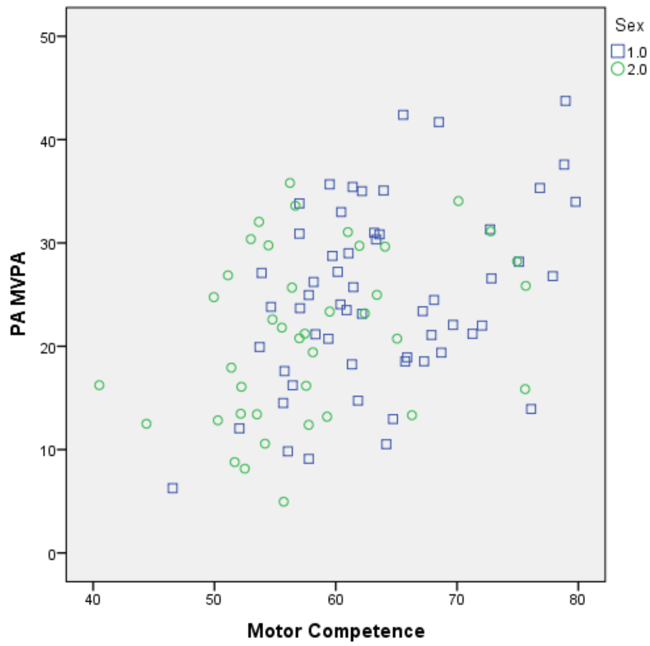

Figure 10 Relationship between duration of moderate & vigorous activity (MVPA, min) and average motor competence.

(r=0.41, P<0.001, Males: square symbol, Females: circle symbol).

Physical Activity: relationship to motor competence, health related fitness and performance.

A summary of the associations observed between objectively assessed physical activity with motor competence, heath related fitness and performance measures is shown in Table 17.

Table 17 Correlation summary of PA with motor competence, health related fitness and performance measures.

	Daily Steps	MVPA
Overall Motor Competence	0.54**	0.41**
Locomotor Competence	0.49**	0.37**
Object Control Competence	0.53**	0.40**
Balance Competence	0.45**	0.35**
Daily Steps		0.73**
MVPA	0.73**	
CV Fitness	0.28	0.31
Speed	0.31**	0.32**
BMI	-0.24*	-0.17
Waist Circumference	-0.18	-0.16

*** Significant at P<0.001, * Significant at P<0.05*

Psychological Domain of Physical Literacy

Three tools were employed to assess the affective and cognitive psychology of the participants related to movement (PLAY Self, PSDQ and MPAM), and results described below. Further, the relationship of each tool to motor competence is reported. Finally, the inter-relationship between the three tools will be described.

PLAY Self

The results of PLAY Self are reported in three sections below corresponding to 1) environmental participation, 2) physical literacy self-description and 3) valuing literacies.

Environmental Participation

The environmental score was different between sexes (P<0.03) with females having a lower score (17.78 (3.05) versus 16.17 (3.91)). Two environments revealed significantly greater environmental scores for the boys than the girls; gym (M: 3.3 (0.71) F: 2.8 (0.90), P<0.01) and outdoor (M: 3.48 (0.57) F: 2.85 (0.91), P<0.001). The scores for water, ice, snow, and playground environments were not significantly different between sexes.

Physical Literacy Self-Description

The correlations between the self-description sub-score (affective and cognitive sub-domains) and each of the thirteen self-description items with motor competence are shown in Table 18. The self-description sub-scores were not significantly different between grade 8 and 12 (67.14 and 67.32 respectively). Males had a significantly greater physical literacy self-description scores) than females (mean difference of 2.54, P<0.05). This sex dependent effect was predominantly due to the differences between the males and females on three questions; #10, 12 & 13 with mean differences of 0.48 (p<0.01), 0.37 (P<0.05) and 0.56 (P<0.001) respectively. Interestingly, left handed participants also reported a significantly lower PLAY Self scores (right handed: 40.73(6.33); left handed: 36.79(3.70), P<0.05) consistent with the motor competence results reported above.

Table 18 Correlation between physical literacy self-description and motor competence.

PLAY Self	Mean score (SD)	r
Physical Literacy Self-Description Score	40.23 (6.17)	0.51**
1. It doesn't take me long to learn new skills or sports or activities.	3.26 (0.69)	0.24*
2. I don't understand the words that coaches and Phys-Ed teachers use.	3.15 (0.78)	0.20*
3. I think I have enough skills to participate in all the sports and activities I want.	3.22 (0.76)	0.41**
4. I believe that being physically active is important for my health and well-being.	3.53 (0.75)	0.37**
5. I believe that being physically active makes me happier.	3.38 (0.77)	0.31**
6. I believe I can take part in any sport/physical activity that i choose.	3.39 (0.69)	0.29**
7. My body allows me to participate in any activity I choose.	3.35 (0.67)	0.33**
8. I worry about trying a new sport or activity.	2.92 (0.88)	0.40**
9. I worry about having enough money to do sports or activities that i like.	2.92 (1.05)	0.22*
10. I am confident to perform activities.	3.13 (0.82)	0.34**
11. I can't wait to try new activities or sports.	2.96 (0.87)	0.23*
12. I am usually the best at doing activity in class.	2.57 (0.87)	0.33**
13. I don't really need to practice my skills, I'm naturally good.	2.45 (0.79)	0.27*

*Significance **P<0.01, *P<0.05*

A relationship between average motor competence and the overall PLAY Self score (Environment and Self-Description scores) was found (Figure 11, r=0.51, P<0.001).

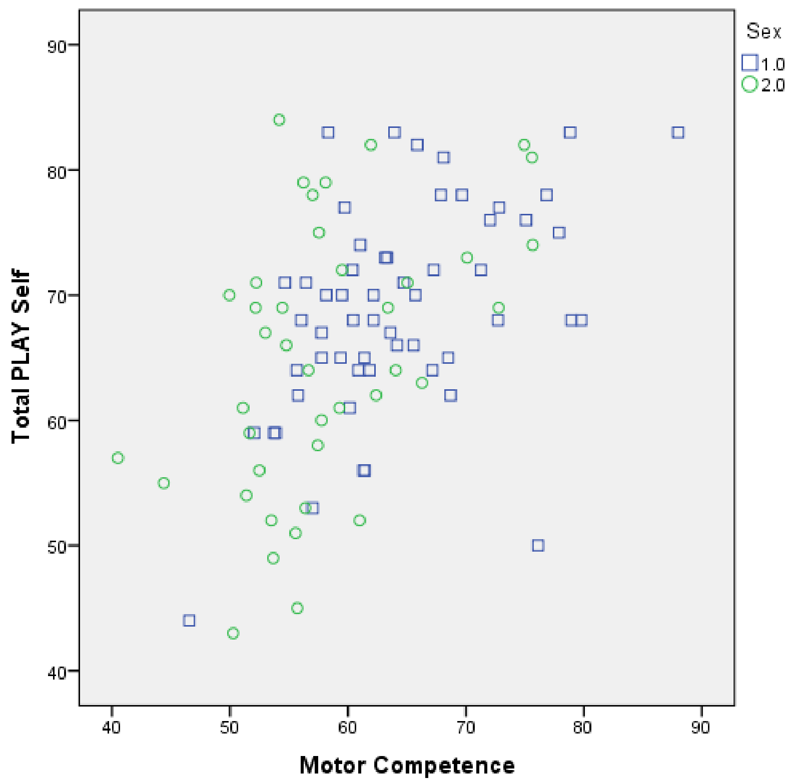

Figure 11. Relationship between average motor competence and overall PLAY Self score
(r= 0.51, P<0.001)

Valuing Literacies

Figure 12 display the rankings of importance of the literacies (read/write, math, movement) in three settings (school, home and with friends). The importance of movement with friends was significantly greater than read/write or math with friends (P<0.001). The importance of movement at home was significantly greater than the importance of read/write or math at home (P<0.01). Movement at school was not significantly different than read/write and math in the same setting. A significant relationship was found between valuing movement literacy in the home environment and average motor competence (r=0.25, P<0.05), but not with the importance of movement in school or with friends. There were no differences in valuing the any of the literacies between males and females.

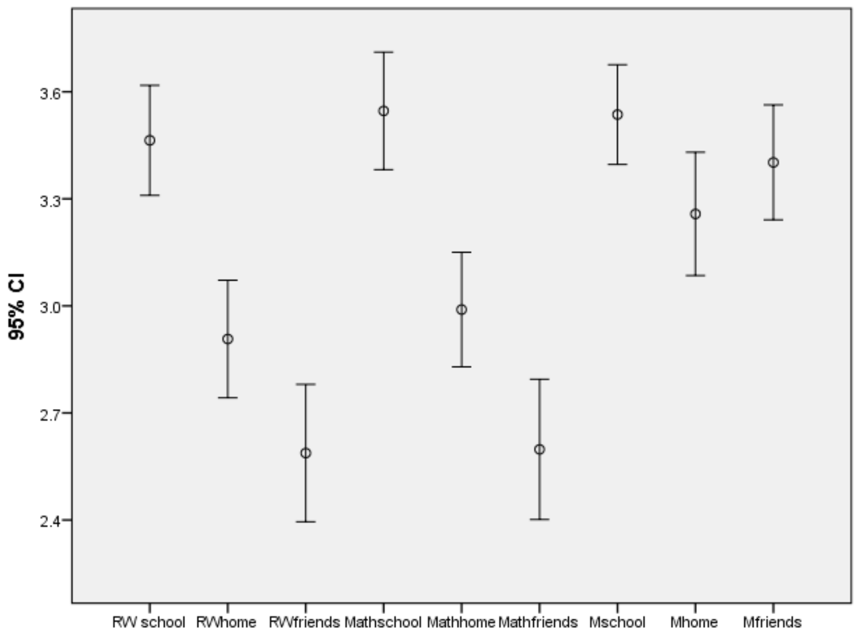

Figure 12 Self rankings of the importance of literacies in school, at home, and with friends.
RW = read & write, Math = math, M = movement, Error bars represent 95% Confidence Intervals

PLAY Self and Health Related Fitness

It was important to explore whether the psychological domain of physical literacy (affective and cognitive components) was, like motor competence, related to the health related fitness assessments. PLAY Self was correlated to speed (0.46, p<0.001) (Table 19) and to CVFIT (0.46, p<0.01). PLAY Self was correlated to BMI (-0.22, p<0.03), but not to WC.

Table 19 PLAY Self (Self-Description) and Performance

	PLAY SELF *(SELF- DESCRIPTION)* GRADE 8 &12
SPRINT SPEED (M/S)	0.46**
CONTROLLING FOR SEX	0.43**
CONTROLLING FOR AGE	0.48**

***Significant at P<0.01*

PLAY Self and PLAY Inventory

The correlation between the total score of PLAY Self and PLAY Inventory was 0.42 (P<0.01). The correlation between the number of teams on PLAY inventory and total score of PLAY Self was 0.47 (P<0.01) and PLAY Self self-description was 0.51 (P<0.01). The correlations between PLAY Self self-description constructs and PLAY inventory is shown in Table 20.

Table 20 Correlations between PLAY Self self-description constructs and PLAY Inventory

PLAY Self Self-description constructs	r
Total score of constructs	0.38**
1. It doesn't take me long to learn new skills or sports or activities.	0.33**
2. I don't understand the words that coaches and PE teachers use	0.25*
3. I think I have enough skills to participate in all the sports and activities I want.	0.26**
4. I believe that being physically active is important for my health and well-being.	NS
5. I believe that being physically active makes me happier.	NS
6. I believe i can take part in any sport/physical activity that i choose.	0.31*
7. My body allows me to participate in any activity i choose,	NS
8. I worry about trying a new sport or activity.	0.29**
9. I worry about having enough money to do sports or activities that i like.	NS
10. I am confident to perform activities.	0.24*
11. I can't wait to try new activities or sports.	0.31**
12. I am usually the best at doing activity in class.	0.25**
13. I don't really need to practice my skills, I'm naturally good.	0.24*

*** Significant at P<0.01, *Significant at P<0.05, NS=not significant.*

Total number of activities recorded in the PLAY Inventory were correlated to the level of self-rated competency in the environmental assessment in PLAY Self (Table 21).

Table 21 Relationships between PLAY Inventory and PLAY Self Environment

Environment	Correlation to PLAY Inventory
Gym	0.28**
Water	0.21*
Ice	NS
Snow	0.26**
Outdoor	0.41**
Playground	0.31**
Total environmental	0.44**

*** Significant at P<0.01, *Significant at P<0.05, NS=not significant*

There was a significant correlation between PLAY Inventory and Total PDSQ (R=0.30, P<0.01) but not MPAM. The number of teams on PLAY Inventory was correlated with both Total PDSQ (R=0.41, P<0.01) and MPAM (R=0.29, P<0.01).

PLAY Self and Physical Activity

Similar to the need to explore the relationship of PLAY Self to health related fitness measures, it was important to establish the relationship to objectively measured PA. The correlation between to total score of PLAY Self and average daily step count was r=0.33 (P<0.001) and duration of MVPA was r=0.31(P<0.01). The correlations between PA and PLAY Self self-description (13 Questions only), and other psychological measures (MPAM and PDSQ) are shown in Table 22.

Table 22 Correlations between PA and PLAY Self Self-description, MPAM-R and PSDQ.

	PA Steps	PA MVPA
PL Self (self-description)	0.30**	0.26*
MPAM-R	0.21*	0.26*
PSDQ	0.29**	0.29**

*** Significant at P<0.01, *Significant at P<0.05*

Accordingly, a stepwise regression predicting physical activity using PDSQ, MPAM and PLAY Self (self-description), only PLAY Self was retained (R^2=0.08, P<0.01).

Physical Self-Description Questionnaire (PSDQ)

A correlation between the PSDQ score and motor competence was found for grade 8 and 12 combined (r=0.50, P<0.001). Correlations separated by grade and sub-domain of the PSDQ are shown in Table 23. From the PSDQ sub-domains, self-rated physical activity had the strongest relationship to motor competence (r=0.56, P<0.01). Global self-esteem also demonstrated a relationship to motor competence in grade 8 (r=0.36, P<0.01) but this relationship was not found in grade 12, likely due to low sample size (Type II error). Males reported a greater self-concept related to physical activity than females (mean difference=0.57, P<0.05).

Table 23 Correlations between PSDQ and sub-domains and motor competence

	Grade 8			Grade 12		
Sample size	n=79			n=19		
PSDQ	**Mean**	**SD**	**r**	**Mean**	**SD**	**r**
Total PSDQ Score	4.55	0.74	.60**	4.33	0.98	.58**
Health	4.68	0.70	.37**	4.60	0.87	.17
Coordination	4.48	0.97	.46**	4.46	1.02	.60**
Physical Activity	4.74	1.23	.56**	4.46	1.11	.63**
Body Fat	4.70	1.13	.42**	4.30	1.69	0.44
Sport Competence	4.53	1.32	.44**	4.06	1.51	.62**
General Physical Self Concept	4.55	1.12	.48**	4.11	1.42	.49*
Appearance	4.23	1.17	.31**	4.11	1.24	.46*
Strength	4.26	1.17	.36**	4.04	1.33	0.42
Flexibility	4.25	1.10	.27*	4.55	0.89	0.29
Endurance/Fitness	4.41	1.06	.46**	3.70	1.50	.67**
Self Esteem	4.94	0.87	.36**	4.90	0.91	0.26

*PSDQ scores – the higher the value the greater the self-concept, scores range from 1-6. **Correlation is significant at P<0.01 level. *Correlation is significant at P<0.05 level.*

Motivation for Physical Activity

The overall score for the Motivation for Physical Activity (MPAM) was correlated to average motor competence (r=0.23, P<0.03). Table 24 reports the correlation between MPAM sub-domains to motor competence. No significant differences in the MPAM scores between grade 8 and 12, or between males and females were found.

Table 24 Correlations between MPAM sub-domains and motor competence

	Grade 8 N=79		**Grade 12 N=19**		**Grade 8 & 12 N=98**	
MPAM	Mean (SD)	**r**	Mean (SD)	**r**	Mean (SD)	**r**
Fitness	5.79 (1.12)	0.32**	5.66 (1.68)	0.17	5.76 (1.24)	0.23*
Competence	5.62 (1.10)	0.41**	5.13 (1.92)	0.42	5.52 (1.31)	0.32**
Interest/ Enjoyment	5.50 (1.20)	0.26*	5.29 (1.70)	0.35	5.46 (1.31)	0.24*
Appearance	4.76 (1.70)	0.01	4.99 (1.56)	-0.21	4.80 (0.17)	-0.02
Social	4.54 (1.41)	0.16	4.96 (1.56)	0.09	4.62 (1.44)	0.17

*MPAM-R scores range from 1-7, where 1 = not true and 7 = very true. ** Significant at P<0.01, *Significant at P<0.05.*

Convergent Validity: Relationship between PLAY Self, PSDQ & MPAM

The total PLAY Self score (environment and self-description) was significantly correlated to the total scores of MPAM (r=0.56, P<0.01) and PDSQ (r=0.78, P<0.01) supporting convergent validity of PLAY Self. The PLAY Self self-description score was also correlated to MPAM (r=0.44, P<0.01) and PDSQ (r=0.79, P<0.01). The relationship between items in PLAY Self self-description with MPAM and PSDQ total scores are shown in Table 25. The inter-dependence among items from each of the tools is reported in Appendix B.

Table 25 Relationships between PLAY Self self-description and MPAM and PDSQ

PLAY Self Self-description constructs	MPAM r	PSDQ r
1. It doesn't take me long to learn new skills or sports or activities.	0.17	0.42**
2. I don't understand the words that coaches and Phys -Ed teachers use	0.23*	0.41**
3. I think I have enough skills to participate in all the sports and activities I want.	0.37**	0.62**
4. I believe that being physically active is important for my health and well-being.	0.33**	0.50**
5. I believe that being physically active makes me happier.	0.34**	0.48**
6. I believe I can take part in any sport/physical activity that I choose.	0.27*	0.51**
7. My body allows me to participate in any activity choose.	0.42**	0.66**
8. I worry about trying a new sport or activity.	0.04	0.40**
9. I worry about having enough money to do sports or activities that I like.	0.03	0.27*
10. I am confident to perform activities.	0.29*	0.59**
11. I can't wait to try new activities or sports.	0.39**	0.44**
12. I am usually the best at doing activity in class.	0.35**	0.55**
13. I don't really need to practice my skills, I'm naturally good.	0.30**	0.43**

*** Significant at P<0.01, *Significant at P<0.05*

Associations among Components of the Physical Literacy Framework

Using the physical literacy framework proposed in the introduction of this thesis, the associations found in this study are reported below (Figure 13).

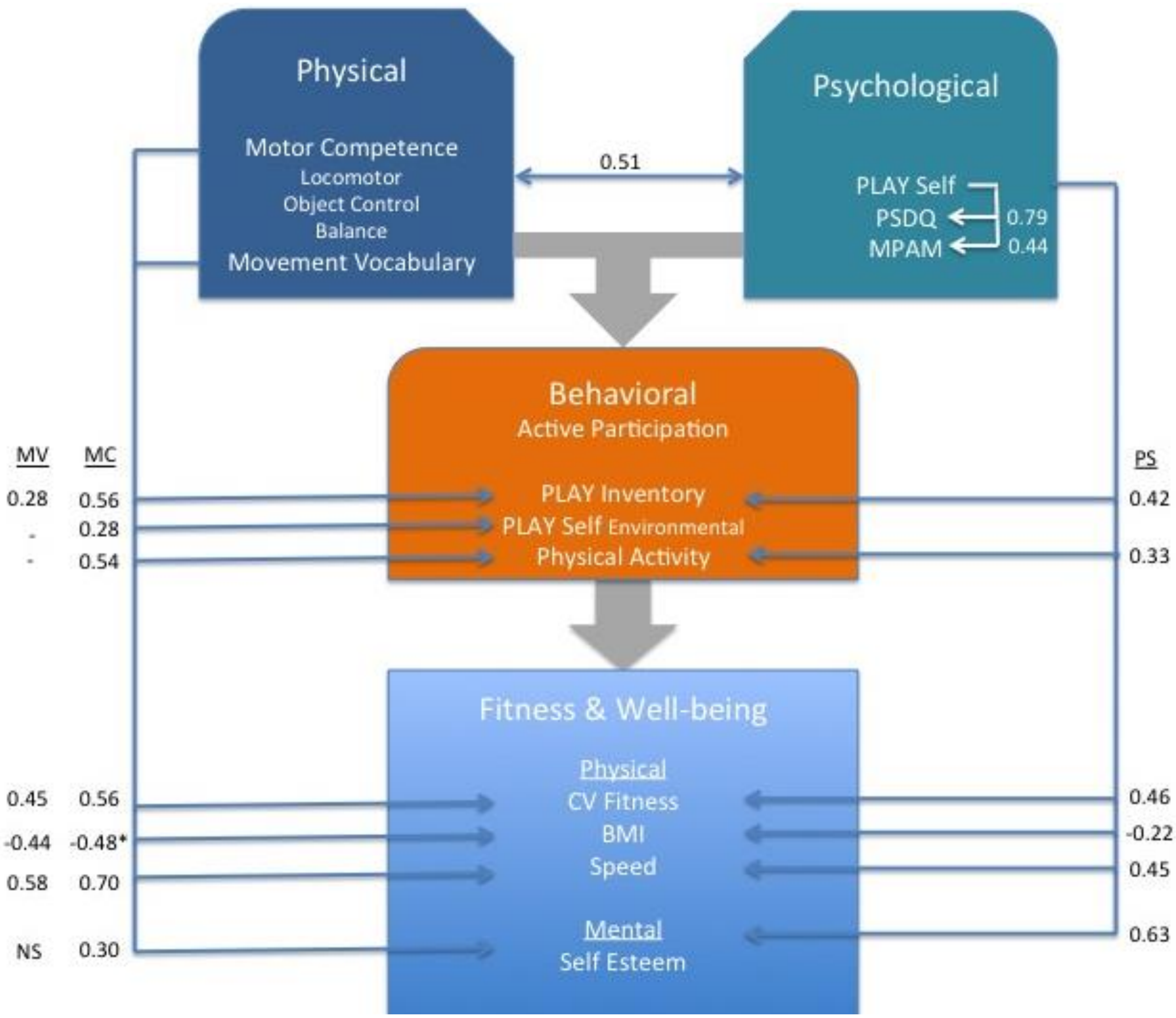

Figure 13 Physical Literacy Framework with Correlations

*All correlations significant at P<0.05. *Significant for Grade 8 only. MC=motor competence, MV=movement vocabulary, PS=PLAY-Self, NS=not significant for movement vocabulary.*

Importance of motor competence

For each significant association for motor competence, a post-hoc analysis was performed where the motor competence score (Play Fun) was binned into the four competency categories (<25, 25-50, 50-75 and 75+). There were very low sample size for the average motor competence below 25, so this category was excluded in the table below (Table 26). Gradients are evident in the means for each dependent variable with motor competence category. For an increase from developing to competent category, there was a speed increase of 1.1 m/s, an increase of 20 shuttles for the cardiovascular fitness, an increase of 1400 steps/day, an increase of 8.3 min/day of MVPA, a 14 cm reduction in waist circumference, and increases in the means of all psychological measures.

Table 26. Motor competence categories associated with performance, fitness, physical activity and psychological measures.

HEALTH/PERFORMANCE INDICATOR	DEVELOPING 25-49.9	COMPETENT 50-74.9	PROFICIENT 75+
SPEED (M/S)	3.81	4.92	5.61
CV FIT (LAPS)	25	45	50
PA STEPS	5345	6749	8592
PA MVPA (MIN)	14.9	23.2	31.0
INVENTORY (#)	21	24	25
WC (CM)	92	78	79
SELF (AFFECTIVE)	36	40	44
SELF (ENVIRON)	15	17	18
PSDQ	3.25	4.5	4.87
MPAM	113	159	165

Mean scores for the health or performance indicator for each motor competence category shown.

Section 2: Run Jump Throw as a Physical Literacy Intervention

Participant Characteristics

Participant characteristics are described in Table 27.

Table 27 Participant characteristics of RJT-PE and PE groups

	N	Age (years)	Height (m)	Mass (kg)	BMI (kg/m²)	BMI (min-max)
RJT-PE						
Total	111	9.44 (0.55)	1.39 (0.07)	35.36 (9.18)	18.22 (3.72)	12.29-29.87
Grade 3	23	8.70 (0.67)	1.34 (0.06)	32.43 (7.88)	17.97 (3.17)	13.62-25.16
Grade 4	88	9.63 (0.28)	1.40 (0.07)	36.13 (9.378)	18.29 (3.86)	12.29-29.87
PE						
Total	77	9.58 (0.54)	1.39 (0.07)	39.01 (11.63)	19.89 (4.71)	12.84-35.61
Grade 3	24	9.03 (0.37)	1.38 (0.05)	39.51 (12.77)	20.81 (5.72)	15.68-35.61
Grade 4	53	9.84 (0.39)	1.40 (0.08)	38.78 (11.21)	19.47 (4.16)	12.84-29.78

Values are mean (standard deviation)

For both grades combined, there was a significant difference in BMI between the RJT-PE and the PE groups, with the PE group having a greater BMI (mean difference = 1.66 kg/m^2, $P<0.01$). In grade 4, there was no difference in BMI between the two groups. However, the mean difference in BMI in grade 3 between the RJT-PE and the comparison group was 2.83 kg/m^2, $P<0.05$). This was due to 3 females and 1 male with high BMI in the PE Group in grade 3. Figure 14 shows the frequency distributions of BMI for the two groups for grades 3 and 4 combined.

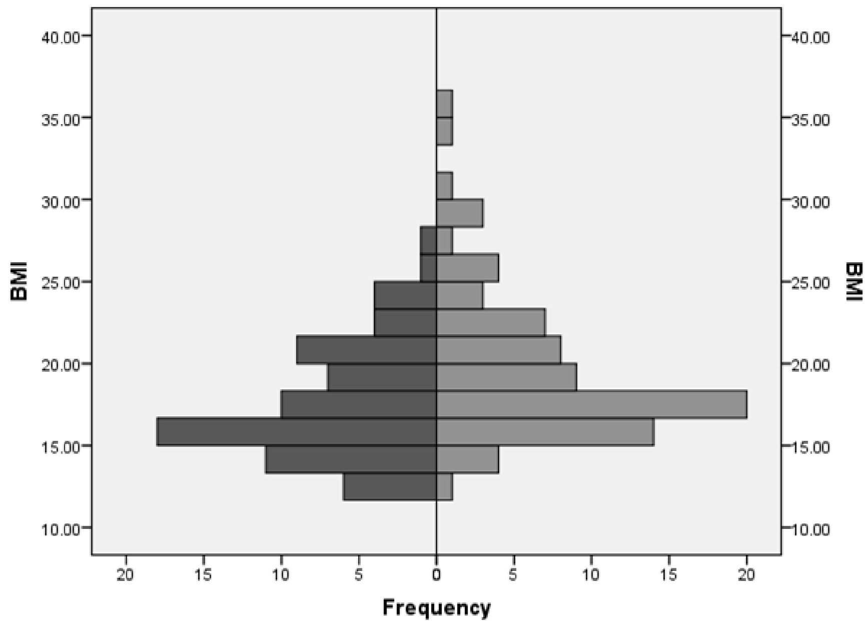

Figure 14 Histogram of BMI for the RJT+PE and PE groups
Dark grey (left) is RJT+PE group and light grey (right) is PE group

Motor Competence

Improvement over time in RJT-PE

The RJT program significantly improved (P<0.01) motor competence over the duration of the intervention time by 5.5% (Table 28). Participants in both grade 3 and grade 4 had similar magnitude of improvement.

Table 28 Motor competence at baseline and endpoint for RJT-PE group

			Pre-Post Intervention	
	Motor Competence Baseline	Motor Competence Endpoint	Mean Difference	P-Value
Total	27.49 (5.89)	32.98 (5.51)	5.49	<0.01
Grade 3	22.35 (4.59)	28.59 (4.99)	6.25	<0.01
Grade 4	28.84 (5.45)	34.13 (5.06)	5.29	<0.01

Values shown are Mean (Standard Deviation).

A comparison of the changes over time in the sub-domains of motor competence for RJT-PE schools in shown in Figure 15. Significant improvements over time for the RJT-PE group were observed for the locomotor (P<0.05) and object control (P<0.05) sub-domains, with the balance sub-domain approaching significance (P=0.07).

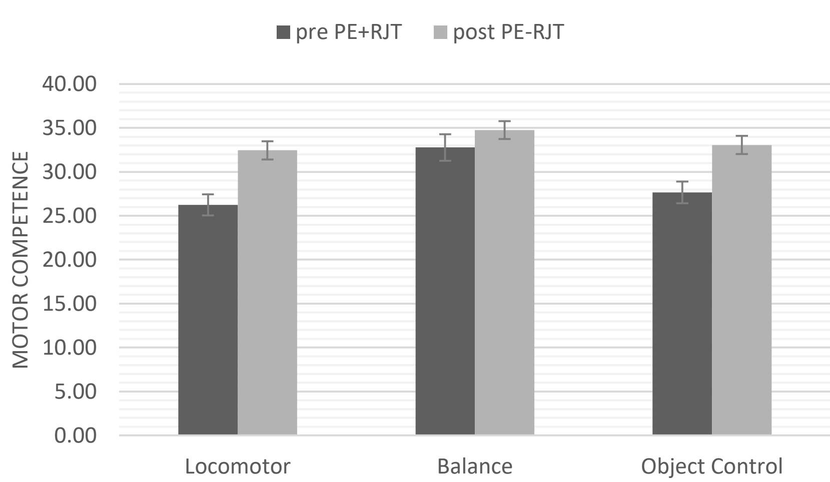

Figure 15 Changes over time for sub-domains of motor competence in RJT-PE group.

Error bars indicate confidence intervals. Locomotor and Object control differences are significant (P<0.01). Balance (P=0.07)

Comparison of RJT-PE to PE Groups

Table 29 shows the average motor competence for the RJT–PE and PE groups in the RJT interventional trial. The pre-intervention baseline motor competence was imputed for the PE group, as described in the study methods. A mixed ANOVA revealed a significant time effect (P<0.01), and between group differences (P<0.05). The between group differences are retained at endpoint (Tukey HSD), whether the ANOVA is performed in crude or adjusted data. In addition to the crude differences, the baseline adjusted values are reported for comparison to other interventional trials.

Table 29 Motor competence of the RJT-PE and PE groups.

		PE Mean (SD)	RJT-PE Mean (SD)	RJT-PE - PE
Grade 3	**PRE**	22.95[i]	22.35 (4.59)	0.6
	POST	25.07 (3.38)	28.59 (4.99) *	3.52 (4.12)
Grade 4	**PRE**	22.99[i]	28.84 (5.45)	-5.85
	POST	25.11 (4.14)	34.13 (5.06) *	9.02 (3.17)

*Imputed values (i) shown for PE. *Significant at P<0.05 after adjustment for baseline differences.*

Achievement of Movement Vocabulary

In the RJT-PE group, participants achieved a greater number of "acquired" competency in tasks over time, with an increase of 4 tasks in the competent category (from 8.62 to 12.70 competent tasks, P<0.001). Thus, overall the participants shifted from the "emerging" to the "competent" category of motor competence. For comparison, the PE group had an average of 2.97 tasks in the competent category at endpoint.

Sex differences

There were no differences in motor competence between males and females in the RJT-PE intervention group at baseline, however there was a significant difference in motor competence between males and females after intervention (Table 30). Examining the sub-domains of motor competence, sex-dependent differences ($P<0.01$) in object control were present between males and females at both baseline and endpoint for the RJT-PE. There were no sex differences in object control in the PE group at endpoint, however they had overall lower motor competence.

Table 30 Sex dependent differences in motor competence

	Males	Females	Difference	P-Value
RJT-PE Group	N=65	N=46		
Total PL Time 1	28.03 (5.98)	26.74 (5.74)	1.29	NS
Total PL Time 2	33.86 (5.26)	31.75 (5.67)	2.11	<0.05
PE Group	N=42	N=34		
Total PL	24.92 (4.36)	25.34 (3.34)	0.42	NS

Values are mean (standard deviation)

Summary of Findings

The first aim of this study was to describe the physical literacy of children and youth, and to examine the inter-relationships of the principle sub-domains of physical literacy and the relationship of these sub-domains to health related fitness, performance and physical activity. The principal findings of Aim 1 are described below.

1. Description of physical literacy in children and youth – the hypothesis that there would be grade dependent increases in motor competence was supported.
2. Sex Differences in Physical Literacy – the hypothesis that there would be sex dependent differences in physical literacy (physical and psychological domains) with male PL exceeding that of females was supported.
3. Physical Literacy with health related fitness, performance and physical activity – the hypotheses that positive correlations between both the physical (motor competence) and the psychological (affective & cognitive) domains of physical literacy and physical activity, cardiovascular fitness and sprint performance, and negative correlations to BMI (grade 8) and waist circumference were supported.
4. Inter-relationship between the Physical and Psychological Domains of Physical Literacy – the hypothesis that there would be a positive associations between motor competence and psychological measures (PLAY Self, PSDQ, MPAM) was supported.

The second aim was to investigate the effects of the Run Jump Throw program embedded in physical education on the physical literacy of children in grades 3 and 4.

1. Run Jump Throw program – the hypothesis that the RJT enriched PE program would demonstrate significant improvements in motor competence over time, and have greater motor competence than comparison schools at endpoint was supported.

Discussion

Physical literacy is a rapidly emerging concept and investigations are required to document the trajectory of physical literacy in children and youth based upon the key components of physical literacy (physical and psychological) that have been proposed in definitions, which have been accepted by consensus, but not yet supported by research. This study provides the first characterization of physical literacy across school age children and youth. Further this study reveals disconcerting differences between males and females in both physical and psychological characteristics. As well, physical literacy is being viewed as a means to enhance active participation in the society for health and fitness benefits, yet with little evidence to support this contention. The moderately strong associations between physical literacy domains (motor competence and psychological) and PA, health related fitness and performance were very important first steps in illustrating the linkages of physical literacy to healthy living. Finally, a purported physical literacy enriched program, RJT, was evaluated to show superior improvements in motor competence to standard PE practices supporting the notion that quality physical literacy experiences in PE are capable of aiding in the achievement of curricular expectations.

Motor competence assessment of children and youth using PLAY-Fun

Motor competence, a keystone component of physical literacy, was shown to be increased in a non-linear manner from grades 3 to 12. In part, this assessment of motor competence over a broad age range (age 7 to 18) was made possible through the use of the PLAY Fun tool, which was a tool designed for assessment of ability rather than detection of disability, which has good discriminative ability, and no apparent ceiling effects. Virtually all other motor development assessment tools (TGMD-2, CAPL) have limitations due to design characteristics in their ability to document motor competence trajectories and discriminate between children's motor proficiency levels. The trajectory of motor development documented herein sets a foundation for future characterization studies, as well as longitudinal, interventional research.

The PLAY fun tool was purposefully designed to assess the movement skills identified in the Manitoba Health and Physical Education curriculum. It was very interesting to note that very few children met the Manitoba curricular expectations for movement skill competency. By grade 4, children are explicitly expected to achieve "entry level" competency (A PLAY Fun score of 50) in 16 of the 18 movement skills assessed, yet only 2.5% of children met this criteria. Even by grade 8 less than 50% of children were reaching the milestones set for grades 4 & 5. Curricula are designed to be progressive, and if the fundamental elements of the movement skill (and corresponding psychological componentry – confidence, etc) section of the curriculum are not delivered in elementary schools, then the ability to layer on complexity in subsequent tears would likely be severely hampered. This could be interpreted that either the curricular expectations are over-reaching or unrealistic, or that the system is not effective in delivering the curriculum. Either way, this study has now established a means by which to examine curricular expectations and achievements. A substantial increase in average motor competence across 18 skills occurred from grade 3 to 4 (just over 6%), and was greater than the increases grade 4 to 8, and from 8 to 12. This may represent the susceptibility of the child to develop these motor skills through normal growth and development at this stage.

Gender gap in physical literacy supported

A gender gap in both the physical and psychological domains of physical literacy was identified. The gender gap in motor competence identified in this study, is certainly not a novel finding, but the extent to which the tools employed in this study documented this gap is unprecedented. A gap in motor competence was characterized from childhood to youth, a feat which has not been performed previously, setting the stage to perform interventional, longitudinal studies to remediate this gender gap. Further, this study concurrently examined not only motor competence differences, but also established psychological differences and tied these to health, fitness and physical activity differences. The concurrent sex dependent deficits in motor competence and psychological items (PLAY Self and PSDQ) has not been previously described, and was recently identified as a key avenue for investigational pursuit by Barnett in 2016. The combined physical and psychological differences represent a substantial deficit in physical literacy in females, despite the fact that the curricular expectations are identical. Females also exhibited lower sprint speed, CV fitness, objective PA levels in terms of steps and time spent in moderate/vigorous, self-concept from PSDQ, and self-reported environmental participation (gym and outdoor use). The PLAY Self self-description score was lower for females due largely to females reporting lower scores for confidence, competence and enjoyment related questions. These findings strongly support the need to remediate this difference through interventional approaches specifically targeted to eliminate this gender gap in physical literacy.

The Canadian Institute of Health Research has mandated research that addresses sex and gender differences, and as such has clearly differentiated between these two terms. As a result of this study, we can postulate that the differences in motor competence are likely gender based, as they originate in children (largely pre-pubescent) and the wedge that is created in childhood likely grows due to the socio-cultural factors rather than the biological differences between the sexes. Further exploration of the socio-cultural factors (barriers and facilitators) need to be performed to help eradicate the differences documented.

Troiano et al revealed a substantial drop of objectively measured PA (% of children meeting PA guidelines) as children went through puberty; 48% to 11% for boys and 34 % to 3.4% for girls (Troiano, Berrigan et al. 2008). The dramatic 10X reduction in PA for the girls could be, in part, attributed to the gender gap in motor competence we identified to commence in grade 4, and the associated psychological manifestations (lower self-confidence, lower competence) that while we did not measure in grade 4, are quite evident by grade 8. Although it needs to be noted that the boys had a greater overall reduction in guideline adherence (37%) compared to the girls (30.6%) in Troiano's study, most likely reflecting an over-arching impact of the socio-cultural impact of a hypokinetic society.

Physical Literacy with health related fitness, performance and physical activity

The finding that the physical literacy domains demonstrated associations with health related measures of fitness, performance and physical activity support the notion that physical literacy may be necessary to a healthy active lifestyle.

Physical activity

A key finding of this study was the correlations of physical literacy (physical and psychological) to objectively measured physical activity. The PL domains and physical activity are discussed below.

Motor competence & physical activity

Recent studies have shown inconsistent relationships between PA and motor competence assessments (Cohen, Morgan et al. 2014, Barnett, Ridgers et al. 2015) which may be due to limitations of the instrument used for motor competence assessment (See Introduction). A recent review (Poitras, Gray et al. 2016) reported very low evidence of a relationship of PA and motor competence (7 studies with mixed results). However data extraction (up to January 2015) for this review was conducted prior to publication of a 6 year longitudinal study that found movement competence was a significant predictor of later physical activity (Jaakkola, Yli-Piipari et al. 2016). Additionally, another recent study demonstrated that physical activity changed with changes in motor competence (Cohen, Morgan et al. 2015). Other earlier studies have shown that childhood proficiency in motor competence explained up to 12% of the variance in self-reported physical activity of adolescents (Barnett, van Beurden et al. 2009), or the presence of correlations up to 0.22 ($p<0.01$) (Cohen, Morgan et al. 2014) and 0.31 ($p<0.01$) (De Meester, Stodden et al. 2016) between MC and MVPA.

In light of these recent findings, it is promising that the PLAY Fun tool has revealed the strongest correlations between PA and motor competence reported to date. This tool provides ability based, holistic assessment across number of motor tasks rather than disability based, criterion based assessment of basic movement skills. Perhaps the characteristics of the PLAY Fun tool allows better discrimination of differences in functional ability allowing for improved correlations to outcomes like PA. For instance, in a study of obstacle course performance (Larouche, Boyer et al. 2014) in grade 4 to 6, a correlation with PA of 0.2 was observed to the obstacle course score based only on four movement skills, and a -0.27 to obstacle course time. The current study demonstrated much stronger correlations (≈ 0.5) between average motor competence and with daily step count and minutes of MVPA, albeit in grade 8 and 12 students. The potential implication of this association (PA to MC of 0.5) is that about 25% of the variance in PA can be accounted for by the level of motor competency achieved by the participants.

If one makes the assumption of partial causality between motor competence and physical activity level, then driving motor competence (through appropriate instructional methods as achieved in the RJT intervention) would result in increased physical activity potentially through the increased participation opportunities presented by enhanced and diverse movement competence (increased vocabulary and increased competence). We also know that increased participation is associated with increased PA. If one partitions motor competence into the 4 categories (post hoc analysis, Table 26), it is evident that increasing motor competence from “developing” to “acquired” would increase step counts by 1400 per day. So if the movement skill expectations of the curriculum were achieved that would translate into a meaningful difference in physical activity. The RJT intervention demonstrated a significantly increased motor competence over time, and improved results in delivery of the curricular objectives over standard PE in just eight weeks. It is tempting to speculate that a year-long PE program delivering quality physical literacy experiences arising from good lesson plans could achieve the curricular objectives, and hence contribute to increased PA levels of children, and hence youth. This speculation must be tempered by the fact that the associations between motor competence and PA are not causal. The results of the cross-sectional study combined with the positive results of the RJT intervention strongly support a RCT which assesses changes in motor competence along with changes in PA.

Certainly, some of the inconsistency between the limited number of studies examining the linkage between motor competence and physical activity may be due to tools utilized and their ability to discriminate between children in functional motor competence (Barnett, Lai et al. 2016, Poitras, Gray et al. 2016). Unlike other motor development assessment tools, the PLAY Fun tool, by utilization of a holistic assessment rubric, allows for the assessment of more than just form based aspects of movement skills, in fact it assesses spatial awareness, motor skill sequencing and even selection. This characteristic may in part explain the higher correlations observed, and needs to be explored into future research studies. Nonetheless, the good associations observed between motor competence and PA, speed, CV fitness are critical first steps in examining if physical literacy is gateway to active participation.

Psychological measures and physical activity

The fact, that moderate correlations of psychological measures (PLAY Self, PSDQ and MPAM) to PA were found is very important. We observed that the multi-construct composite score from PLAY Self is associated (r=0.33) to objectively measured PA. In fact, PLAY Self had higher correlations than PSDQ or MPAM to PA. This may reflect that for each individual a different combination of psychological constructs are at play in contributing to the behaviours that an individual adopts, in this case PA. Certainly, self-confidence and self-assessed competence were key items but all the constructs assessed in PLAY Self from worry to happiness were associated. Our findings match with some of the limited work that has been performed to date on relating psychological factors to PA. For instance Timo and colleagues reported perceived physical competence is related to self-reported MPA and VPA between early and late adolescents in a 6 year longitudinal study (Timo, Sami et al. 2016). Of course, the limitation in their study, although consistent with our findings, is that self-reported PA has been found to be a substantial over-estimate of actual PA (Troiano, Berrigan et al. 2008), and that the over-estimation may be related to self-assessed competence. In very young children (age 4-8) perceived physical competence was associated with actual physical competence yet neither were associated with PA, perhaps due to the young age of the children (Barnett, Ridgers et al. 2015). Others have found positive correlations between perceived competence and PA, r=0.17 (De Meester, Stodden et al. 2016). This lower correlation than ours may reflect that it is not perceived confidence alone that contributes to PA and that the PLAY Self more accurately represents the variety of psychological aspects involved in being physically active. Nonetheless, the linkages that have been established between psychological factors and PA are critical to document, so as to help develop effective interventions in the inactivity crisis that combine both mental and physical approaches. A key additional element that needs consideration is "what are the pedagogical approaches that develop self-confidence and other psychological aspects at the same time as developing motor competence and at what developmental stage is this critical to develop or sustain?”

Sprint Performance

Many sport organizations across countries hold that physical literacy is a critical element to the development of an athlete (long term athlete development), and this notion is partially validated by our findings. Athletes require the ability to execute coordinated movement using rapid skill selection and sequencing demonstrating spatial awareness, *and* have the necessary confidence and motivation to perform successfully. This study demonstrated a positive relationship between sprint performance and physical literacy (both physical and psychological domains) even after controlling for age. Establishing this link was important as it contributes to the identification of the foundational competence level that may be necessary for success in running events. Further study is needed to determine what that baseline foundational competence (both physical and psychological) is. This study also demonstrated the utility of the PLAY tools (PLAY Fun and PLAY Self) across both developmental and high performance settings in that it did not reveal a ceiling effect with even the fastest sprinters.

Body composition

The finding that BMI was not correlated to motor competence in grades 3 and 4 was a surprise, and certainly a novel finding, as we initially launched into this study with the notion that overweight and obesity was a barrier to development of motor competence, based upon previous research which documented BMI dependent motor competence (Hands, Larkin et al. 2009, Vandendriessche, Vandorpe et al. 2011, Cliff, Okely et al. 2012, Cattuzzo, dos Santos Henrique et al. 2016) albeit through categorical statistical methods. The lack of association we observed using the continuous data set, despite fairly large sample size capable of detecting correlation coefficients down to ≈0.23, is consistent with the notion that other socio-cultural factors are at play at this early age limiting physical activity participation, and the body composition is not as significant a barrier as perhaps was surmised at this age. When we employed a categorical approach (which artificially reduced variance) like previous studies by dividing into overweight/obese and normal weight categories we did find a similar relationship (Okely, Booth et al. 2004, D'Hondt, Deforche et al. 2011, Cliff, Okely et al. 2012). However, like previous studies, we confirmed that in adolescence (in Grade 8), the moderate, and as expected, negative correlation between motor competence and BMI materialized. Certainly, the findings of this study establish the need to examine the factors that precipitate this shift from grade 4 to grade 8. It is possible that the lack of motor competence at these early ages is dependent upon the valuing of developing movement skills, and the valuing of PE in schools on the delivery of the curriculum rather than the body composition characteristics of the child.

Cardiovascular fitness

Previous studies have established the relationship between motor competence and cardiovascular fitness with correlations up to 0.61 in children (Haga 2008, Vedul-Kjelsas, Sigmundsson et al. 2012, Haga, Gisladottir et al. 2015) but not present in adolescents

(Haga, Gisladottir et al. 2015). Our finding that this relationship can be found in grade 8 adolescents (r=0.56), and particularly in the locomotor sub-domain, may be due to the strength of the PLAY Fun assessment tool in that it does not have ceiling effects. Psychological self-description also demonstrated a similar association to cardiovascular fitness which is consistent with other findings (Vedul-Kjelsas, Sigmundsson et al. 2012). This finding in this age group is an important one as the health risks of poor cardiovascular fitness are well known and exploration of the possibility that better fitness may be the result of improving physical literacy (both physical and psychological) should be conducted.

Interpretation of the Relationship of Motor Competence to Health Related Fitness, Physical Activity and Psychological Measures

A post hoc examination of the correlations between motor competence and health related fitness, performance and PA revealed correlation coefficients values ranging from 0.29 to 0.86 (Table 17) which corresponds to a coefficients of determination range of 8 to 74%. Table 26 outlines the change in health related fitness, performance, PA and psychological measures corresponding to a change in motor competence category. The magnitude of these changes would certainly be meaningful. So, through appropriate intervention (achievement of the motor competence expectations in PE, and therefore psychological benefits in confidence, enjoyment and motivation) meaningful differences in health related fitness, performance and physical activity levels could be achieved. Certainly the RJT intervention study reveals that the motor competence is mutable with appropriate intervention. Future interventional studies, need to evaluate not only motor competence but other psychological and social factors involved in active participation, as measured by inventory of activities or by objectively measured PA.

Inter-relationship between the physical and psychological domains of physical literacy

A recent meta-analysis of motor development (Barnett, Lai et al. 2016), echoing an earlier review (Lubans, Morgan et al. 2010), identified a critical need to examine the relationship between psychological parameters and motor competence for understanding the interplay between the two to help design interventions, but also to understand the differences between the sexes in motor competence and physical activity. This study is one the first to document a moderate inter-relationship between the affective and cognitive psychological domains and motor competence, and further to illustrate numerous linkages between key psychological constructs (confidence, enjoyment, motivation) and motor competence supporting the inclusion of these elements as essential components in physical literacy (Figure 13), as well as to fitness and physical activity outcomes (Figure 13).

All of the psychological instruments (PLAY Self, PSDQ, MPAM) aggregate scores were related to motor competence, with PLAY Self the strongest. Additionally, the PLAY Self construct correlations (Table 18) of perceived competence (Q3), cognitive (Q4), enjoyment (Q5), confidence (Q10), and motivation (Q11) to motor competence support the connection between the physical and the psychological domains of physical literacy. These findings also support the notion of an inter-relationship between self-perceived competence with actual competence. This realization of self to actual, may be involved in the generation of self-confidence in movement. During the development of motor competence, we propose that there is a concurrent process which ties perceived competence, and self-confidence (in essence self-efficacy) with actual motor competence, and this must be achieved through some sort of realization mechanism. Interestingly, the RJT interventional study used reflection as a means to foster self-realization of competence. In fact, Kiez (2015) demonstrated that using a circus arts instruction in PE led to increased motor competence combined with enhanced self-confidence (PLAY Self) and confidence assessed during execution of motor tasks in a similar age group. Further research is needed to elucidate the mechanism by which self-confidence arises during motor competence development.

A physical literacy cycle has been proposed which ties movement competency to confidence to motivation to participate in activity (Taplin 2013). The results of this study certainly support this positive feedback cycle, albeit through association. This is an important contribution as this helps to develop the notion that physical literacy may be a gateway to active participation and hence better mental and physical fitness. The cognitive-affective personality system was proposed in 1995 (Mischel 1995) and suggest that behaviour is predicted by understanding the person, the situation and the person's interaction with the situation. The PLAY tools (PLAY Fun and PLAY Self) provide an assessment of the person, their perception of the situation (interaction), and in so doing may provide better insight into physical activity behaviours than simple motor competence measures when applying the cognitive-affective personality perspective to physical activity behaviours. The moderate ties between the psychological and motor competence domains of physical literacy, and the concurrent ties of both of them to behaviour (participation and PA) (Figure 13), and ultimately to fitness is a critical first step in understanding factors that lead to a healthy lifestyle.

The Canadian physical literacy consensus statement identifies four domains of physical literacy; affective (PLAY Self), cognitive (PLAY Self), physical (PLAY Fun) and behavioural (PLAY Inventory). This study described elements of each of the domains with the affective and cognitive collapsed into psychological assessed by PLAY Self. The fair to moderate interrelationships between the psychological, physical and behavioural were documented (Figure 13), supporting the need to maintain these components with the overall physical literacy construct. Certainly, the correlations were much stronger than previous reports (Barnett, Ridgers et al. 2015, Barnett, Lai et al. 2016, Poitras, Gray et al. 2016). Future studies, some of which are ongoing, need to use structural equation modeling or factor analysis to determine the key components of overall construct. A primary contribution of this work was the identification of inter-relationships among sub-domains of physical literacy that will form the foundation for the further development of the physical literacy construct.

Convergent validity of PLAY Self

This study provided a first step in the confirmation of the construct validity of the PLAY Self. The PLAY Self demonstrated good concurrent validity to two well established related psychological measures; the PDSQ and the MPAM. The moderately strong association with the PDSQ (r=0.78) by PLAY Self, is an important finding for physical literacy researchers as the PLAY Self is much easier and less time consuming to administer than the PDSQ. As a motivation to physical activity measure, rather than a psychological self-description measure, the MPAM demonstrated the expected slightly less strong correlation (r=0.56) to PLAY Self. This important first step in validating the PLAY Self can assure future users of the tool that it is a useful tool for the assessment of physical literacy (psychological domain).

Positive effect of physical literacy intervention

The interventional trial undertaken in this study is the first of its kind to examine the impact of an implementation of a specifically designed program for developing physical literacy – Run Jump Throw- on one of the key components of physical literacy (motor competence). This study used a tool to assess motor competence across skills that were strongly linked to curricular expectations. Interestingly, the RJT program was, in part, designed to develop many of these skills through lesson plans which provide repetition based learning of movement skills with knowledge of results in a safe, inclusive and socially facilitated manner. The expectations of the RJT implementation then, would be to increase motor competence in skills taught, and as a result increase the number of movement skills reaching entry level competency. That is, creating a greater movement vocabulary for children. The 8 week quasi-experimental trial revealed improved motor competence, and increased movement vocabulary in the RJT arm of the study. When compared to the matched schools, the endpoint motor competence was substantially better in the RJT schools. In order to account for the fact, that a baseline measurement was not performed for the comparison schools (to control for contamination bias), we imputed the baseline.

We used data from the control arm of very similar study (Kiez 2015) for imputation to reveal that the significant and substantial differences still persisted. In essence, when controlling for normal growth and development, and for standard physical education implementation, the RJT program was effective in enhancing motor competence in object control and locomotor skills. This study, in essence, is an efficacy trial for the RJT program supporting its use.

Comparison to other motor competence intervention studies

A meta-analysis of motor competence interventions reported significant intervention effects with large effect sizes for overall gross motor proficiency and locomotor skill competency and medium effect size for object control skill competency (Morgan, Barnett et al. 2013) across a large age range. However there are a limited number of studies (Table 31) that have examined motor competence interventions in the same age group as this study.

Table 31 Motor competence interventional improvements reported in other studies

Intervention program	Duration of program	Study population information	Results
PL Circus (Kiez 2015)	3 months	Grade 4 and 5 children	7.8% Improvement in MC
Michigan's Exemplary PE Curriculum (Boyle-Holmes, Grost et al. 2010)	1 year	Grade 4 and 5 children	Significant Improvement in MC (Intervention > Standard PE Comparison – Value not reported)
Move it Groove it (van Beurden, Zask et al. 2002, Beurden, Barnett et al. 2003)	1 Year	Age 7-10 children	16.8% Improvement in MC
SPARK (McKenzie, Alcaraz et al. 1998)	6 months	Grade 4 and 5 children	21% Improvement in MC
Athletic training (Katic, Males et al. 2002)	6 months	7 year old girls	Significant Improvement in MC (object control & locomotor -Value not provided) over Comparison group (standard PE)

The Get Skill, Get Active research team (van Beurden, Zask et al. 2002, Beurden, Barnett et al. 2003) in Australia investigated the Move it Grove it program designed for children aged 7 to 10 using a quasi-experimental design (no control) over a 1 year duration (n = 1000). This was a school wide intervention resulted in an improvement of 16.8% across movement skills assessed. Given the much shorter duration of the RJT intervention used in this study (8 weeks), the change in motor competence needs to be scaled to similar duration resulting in an improvement of 3.2% over the same time frame. The RJT program improvement over time was 5.5% which exceeded that of the Move it Grove it program when time normalized. This is impressive especially since the RJT program was confined to the PE setting and was only implemented in 75% of PE classes.

Mckenzie et al in 1998 performed a clustered RCT over 6 months duration on 709 children in the USA using the SPARK interventional approach in grades 4 and 5 children comparing three groups; PE specialists, trained teachers and control (usual practice) (McKenzie, Alcaraz et al. 1998). They only examined motor competence of three manipulation movement skills (overhand throw, catch and kick). Over the 6 month duration, the PE specialist increased motor competence for these three skills by 21%, the trained teacher by 19% and the control increased by 13%. So relative to control, the PE specialists achieved an 8% improvement in motor competence of object manipulation skills over 6 months. Adjusted to the RJT duration of 8 weeks, the SPARK program would have achieved a 3.3% improvement relative to control in just object manipulation skills, while the RJT intervention group achieved about a 3.5% greater average motor competence relative to control. The average motor competence responses to intervention (3.5%) would be blunted relative to changes object control sub-domain due to averaging of body control/balancing tasks. A direct comparison of the change in object manipulation in this study to the change in object manipulation reported by Mackenzie et al in (1998) is worth pursuing.

The interventional study showed that RJT employed as a quality physical literacy experience in PE was superior to standard PE practices in developing motor competence in children. This is consistent with a meta-analysis on the effect of motor competence intervention programs where mastery based learning over games based learning in PE was shown to be superior in the development of motor competence (Morgan, Barnett et al. 2013). Overall, these findings have immediate and important implications for the development of physical literacy in children in the education sector, but also could be used for refinement of programs in recreation, sport and early childhood education.

Limitations and Delimitations

A number of delimitations and limitations existed for this study.

This study is delimited to a Manitoba context where there is a relatively high number of PE classes per week relative to the rest of Canada, and there is a high per capita number of PE specialist teacher, as well as mandatory PE from K to grade 12. As such, the findings of this study may not be applicable to other jurisdictions.

The sample size for the grade 12 groups was relatively small, and this could contribute to the generation of both Type I and Type II errors. We believe that the failure to detect differences in locomotor and balance competence was likely a Type II error. We decided to retain the data for exploratory reasons and caution is advised in generalization of results that directly stem from grade 12 data.

During the motor competence assessment all students were encouraged to perform the task 'as best they could'. The group testing may have stimulated competitiveness with some of the students which may have improved or reduced their performance. Observation of other students performing the tests may also have influenced performance. However, the PE teacher engaged the students in other PE activities in another part of the gymnasium to minimize observation of the assessments.

Not all of the PLAY tools were available for the assessment of grade 3 and 4, since some of the tools were still in the development process. This limited some of the analysis of inter-relationships in relation to grade.

A limitation of physical activity with accelerometers is that they were not worn during sport competitions or in any water activities. This would have under-estimated activity levels for certain competitive athletes. Additionally, accelerometers under-estimate energy expenditure arising from cycling, so children using cycling transport or those that were training on stationary or road cycling would have their physical activity under-estimated.

In the RJT quasi-experimental trial we used a convenient sample (not randomized) of rural and urban schools that expressed interest in participating in the RJT interventional arm of the study. The specific bias that is important to consider in this trial is selection bias that may have occurred by permitting the schools to choose to participate in the RJT trial while the non-RJT schools did not have that same opportunity. This may have resulted in a bias toward schools that were better prepared and interested in implementation of quality physical education programming. We attempted to partially control for this by selection of comparison schools that had, at face value, similar traits geographically, socioeconomic status and with similar teacher qualifications. Despite this, there may be an increased tendency toward a favourable result due to the interest in pursuing the Run Jump Throw programming in the school. As well, we decided to not measure the comparison schools at time 1, due to the risk of exposing the PE teachers to the evaluation tool (PLAY Fun) and potentially having them teach to the tasks. This resulted in the lack of directly measured baseline data. As a result we had to rely on imputation to infer the baseline values. We believe that the threat posed by non-equivalence between test groups was reasonably well mitigated in this experiment.

A large number of correlations were performed in this study, and as such 5% of the results may be spurious and due to chance (Type 1 errors). Type 1 errors are random by definition, and in this study we observed very strong clustering of associations which mitigates against acceptance of Type 1 errors as real. However, some of the correlations my still have arisen due to chance, but even exclusion of some the results does not substantively alter the principal findings of the study.

Conclusions

Two sub-domains identified for physical literacy are motor competence and the affective psychological domain. This study is the one of the first to demonstrate moderate connections between them revealing that self-assessed confidence, competence, enjoyment and happiness among others are tied to actual motor competence. This partially supports the physical literacy cycle proposed by Liz Taplin (competence->confidence->motivation) as well as the physical literacy framework developed in our lab.

A gender gap was observed in motor competence that widen with age especially for object control. A gender gap was present in CV fitness, speed, body composition, participation and psychological measures. This is one of the first studies to document the gender gap in terms of multiple facets, and even though the differences were cross-sectional, and the relationship associative (not causal), the findings are disconcerting and need to addressed.

It was important to demonstrate the relationship between motor competence and physical self-description (affective psychological domain of physical literacy) to participation and physical activity levels. The existence of moderate correlations, although not causal, is reassuring and supports the notion that physical literacy may be a gateway to active participation.

Physical literacy shows appropriate linkages to indicators of a healthy lifestyle in two key domains, physical and psychological. The gender gap in physical and psychological differences is alarming, and requires studies aimed at remediation. These results support the notion that PL may be a gateway to physical activity in youth, and that PL can be enhanced by means of quality PL enriched lesson plans in schools.

Future Studies

The RJT quasi-experimental study reported here has set the stage for a large scale, clustered RCT which could have multiple interventional arms comparing different PE programming approaches including RJT.

The results of this study documenting gender differences across a number of domains would be bolstered by a mixed methods design (qualitative and quantitative) to delve deeper into the underlying factors that create these disconcerting differences. This could be followed up with a clustered RCT which has a standard PE arm and an arm which is designed to eliminate the gender gap.

It is important to longitudinally examine the relationship between motor competence and physical activity, in particular changes in motor competence with changes in physical activity.

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Appendix A

Sample Consent/Assent Form

UNIVERSITY OF MANITOBA

Adolescent ASSENT Form

Study title: An examination of physical literacy in adolescents

Investigators: Tanya Kozera and Dean Kriellaars

This form tells you about the research study and asks if you would like to take part in the study. If there is anything you do not understand, please ask your parent or guardian or the study staff.

The study staff would like to learn more about the relationship between physical literacy (how well you move) and physical activity and how these relate to your leisure activities, motivation, self-esteem, and sleep quality. We believe this is important because we want to find out if physical literacy has an effect on physical activity levels and fitness, and if how teens feel about themselves and what they participate in influences their physical literacy. Once started, the study will last about 1 week.

If you want to be in this study, the following will happen;

1. We will measure your physical literacy by asking you to perform 18 different skills/tasks.
2. We will ask you to complete questionnaires about
    a. your leisure activities
    b. your self esteem
    c. your motivation
    d. your sleep habits
    e. your self assessment of physical literacy
3. You will wear an accelerometer (a small pager like device) that measures physical activity for 1 week and complete an activity diary for that week.
4. We will also collect basic information about you such as age, height, weight, and waist circumference
5. We will collect fitness test information regarding 15 meter sprint time and the 20 meter shuttle run test.

Potential benefits include a greater understanding of what makes adolescents active. There are no direct benefits to you. Potential adverse events from taking part in the study include the usual risks of physical activity such as falling and getting injured. The likelihood of this is considered to be no more than that would occur from normal daily activity.

You may ask your questions any time, now or later. We would also be happy to meet with you to answer any questions you may have about the study, Tanya can be reached at XXX-XXXX or XXX-XXXX or Dean can be reached at XXX-XXXX.

Any information you give to the study staff will be kept private. Your name will not be on any study paper and no one but the study staff will know that it was you who was in the study.

You do not have to be in the study. No one will be mad at you if you don't want to do this. If you don't want to be in this study, just say so. Even if your parents want you to be in the study you can still say no. Even if you say **yes** now, you can change your mind later. It's up to you.

Do you have any questions?

What questions do you have?

Assent

I want to take part in this study. I know I can change my mind at any time.

____

Print name

________________________ ___________ ________________

Child's Signature **Age** **Date**

I confirm that I have explained the study to the participant to the extent compatible with the participants understanding, and that the participant has agreed to be in the study.

_____________________ ________________ _____________

Printed name of Person obtaining assent | **Signature of Person obtaining assent** | **Date**

Version February 13 2012

Appendix B

Sub-constructs of MPAM and PSDQ to PLAY Self self-descriptions Items

Table 29 outlines the selected overlapping constructs between the subcomponents of MPAM with PLAY Self. There are fair to moderate correlations between the overlapping constructs of PLAY Self and MPAM, especially related to competence and enjoyment.

Table 30 depicts the correlations between selected overlapping constructs of PLAY Self with PSDQ. There are moderate correlations between competence, coordination and fitness items in the PDSQ with PLAY self (Table 30). Other significant correlations (P<0.01) between PLAY Self self-descriptions and PDSQ were as follows; Question # 3: Physical Activity (R= 0.46) and Global Self Concept (R=0.45), Question # 4: Health (R= 0.47), Question # 7: Self-esteem (R=0.54), Appearance (R= 0.53), and Global Self Concept (R=0.52), Question # 10: Health (R=0.51) and Global Self Concept (R=0.51) and Question #12: Health (R=0.46) and Global Self Concept (R=0.45).

Table 32 Correlations between PLAY Self self-description and MPAM domains

PLAY Self Self-description constructs	Competence	Fitness	Appearance	Interest/ Enjoyment	Social
1. It doesn't take me long to learn new skills or sports or activities.					
2. I don't understand the words that coaches and Phys-Ed teachers use					
3. I think I have enough skills to participate in all the sports and activities i want.	Competence 0.41			0.38	
4. I believe that being physically active is important for my health and well-being.		0.43		0.36	
5. I believe that being physically active makes me happier.		0.35		Enjoyment 0.35	
6. I believe I can take part in any sport/physical activity that I choose.					
7. My body allows me to participate in any activity I choose,	Competence 0.45	0.39			
8. I worry about trying a new sport or activity.					
9. I worry about having enough money to do sports or activities that I like.					
10. I am confident to perform activities.	Competence 0.44			Enjoyment 0.37	
11. I can't wait to try new activities or sports.	Competence 0.49	0.40		Enjoyment 0.49	
12. I am usually the best at doing activity in class.	Competence 0.45				
13. I don't really need to practice my skills, I'm naturally good.					

All correlations are significant at $p<0.01$.

Table 33 Correlations between PLAY Self self-descriptions and related PDSQ domains

PLAY Self Self-description constructs	Sport competence	Coordination	Endurance/ fitness
1. It doesn't take me long to learn new skills or sports or activities.		0.51	
2. I don't understand the words that coaches and Phys-Ed teachers use			
3. I think I have enough skills to participate in all the sports and activities I want.	0.51	0.59	0.48
4. I believe that being physically active is important for my health and well-being.		0.47	
5. I believe that being physically active makes me happier.			
6. I believe I can take part in any sport/physical activity that I choose.		0.50	
7. My body allows me to participate in any activity I choose,	0.51	0.59	0.57
8. I worry about trying a new sport or activity.			
9. I worry about having enough money to do sports or activities that I like.			
10. I am confident to perform activities.	0.57	0.55	0.54
11. I can't wait to try new activities or sports.	0.49	0.49	0.45
12. I am usually the best at doing activity in class.	0.52	0.54	0.50
13. I don't really need to practice my skills, I'm naturally good.		0.47	

All correlations are significant at p<0.01.