Agility as a predictor of physical literacy, activity levels and sport involvement

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Abstract: Objective: Given the increasing importance being placed on levels of youths’ physical literacy (PL), physical activity (PA) and sport involvement (SI), it would seem plausible to investigate a common physical activity outcome (PAO) that would go to predict success throughout these domains. The impact of various demographic variables, on physical performance, is of interest. This study hypothesised that levels of agility predict the success in a number of PAOs.

Design: A variance (ANOVA), with repeated measures, was conducted to determine if the physical performance responses differed significantly from each other for selected PAO.

Setting: Two hundred and thirty-four (234) school-aged students (11–17+ years) had data (quantitative) collected across six PAOs, which were selected based on their inherent connections to domains.

Method: Correlation matrices and Structural Equation Modelling (SEM) were further used to examine and diagrammatically represent the significance (p < 0.05—p < 0.000) of associations and relationships (r) between levels of agility and each PAO.

Results: Strength of the direct effect identifies that higher levels of agility, being male (r = .208**, p < 0.001) and a light—moderate BMI (r = .223**, p < 0.05), significantly moderates the pathways between all PAOs. The SEM indicated that the
approach fits the data set very well (p < .05, Chi Square/DF<3, and other fit values in the .95–1.00 region).

**Conclusion:** Findings suggest that more attention should be directed towards promoting the inherent benefits of improving school-aged students’ agility levels, with an aim to developing reciprocating positive impacts on domains.

**Subjects:** Teachers & Teacher Education; Childhood; Early Childhood; Curriculum Studies

**Keywords:** agility; physical literacy; physical activity; sporting involvement; rugby league; junior participation

1. Introduction

Given the increasing importance being placed on levels of youths’ physical literacy (PL), physical activity (PA) and sport involvement (SI), it would seem plausible to investigate a common physical activity outcome (PAO) (i.e. agility) that would go to predict success throughout these domains. Similarly, the impact of various demographic variables, on physical performance, is of interest. It is thought that such an investigation would go towards assisting in tailoring future physical education (PE) programs aimed at heightening children’s competency levels in PL, PA and SI.

1.1. The importance of agility

There is a growing interest in the factors that influence agility performance (Lovell, Bocking, Fransen, & Coutts, 2018) and how agility, in turn, improves sporting performance (Paul, Gabbett, & Nassis, 2016). However, there is limited, co-ordinated research, that goes to examine agility as a predictor of successful PL, PA and SI levels of school-aged students (11–17 + years). This limited research, may, in part, be due to commonly held beliefs that junior performances have little predictive value for assessing the future success of young players’ potential (Faber, Bustin, Oosterveld, Elferink-Gemser, & Nijhuis-Van der Sanden, 2016) and the lack of longitudinal studies precludes verification of instruments’ capacity to forecast future performance (i.e. agility tests) (Jeffreys, 2011).

The physical components that need to be consolidated and are deemed necessary for students to perform successfully in sporting events and to be physically literate, consists of many fundamental (foundational) motor skills, being: to run, shuffle, bend, change direction, anticipate, to backpedal at speed, with the added complexity of accurately manipulating equipment and executing techniques. Of interest, is how these physical components are introduced and re-enforced throughout the Australian Health and Physical Education Curriculum. Findings from this research go to support the importance of students becoming physical literate (proficient in movement), thus improving their capabilities and potential to be active participants rather than passive recipients within a PA environment. The Australian Health and Physical Education Curriculum goes to support the development of tailored approaches to learning environments that are aimed to heighten movement confidence (PL) and PA participation by way of:

- Synthesising information to take positive action to enhance students’ PA participation across a lifespan,
- Acquire, apply and evaluate movement skills, concepts and strategies to respond confidently, competently and creatively in a variety of PA contexts and settings,
- Engage in and enjoy regular movement-based learning experiences and understand and appreciate their significance to personal, social, cultural, environmental and health practices and outcomes (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2016).

What is more, sports that heavily utilize these types of motor skill-related PL components, are many and varied, however, such SI within rugby, soccer, and basketball require players to have a highly advanced level of agility to be successful (Gambetta, 1996; Jeffreys, 2011; Lloyd, 2015).
Athletes need to have the ability to change directions and positions quickly on a horizontal plane, thus giving them an advantage over opponents and puts them in positions that are able to enhance performance and techniques. Similarly, agility is a frequently stated PAO, that is seen as an important building block for childhood PL and SI success (Lloyd, 2015; Whitehead, Maccallum, & Talbot, 2012) and subsequently, for promoting heightened and lifelong engagement in PA (Longmuir et al., 2015). Importantly, the undertaking of this research is seen as a possible starting point/predictor for new ways of thinking, pertaining to the development of future school-aged students’ successful PL, PA and SI levels. Future research, at the adolescent level, should focus on a multidisciplinary approach to fostering youths’ physical domains making such a research undertaking warranted.

To gain a better understanding as to the body of work in this field, electronic searches were conducted in Google Scholar, PubMed, ProQuest, Web of Knowledge, ScienceDirect (2010–2018). Search terms represented “teens/youth/school aged students + agility impacts + PAO + PL, PA and SI”. Multiple search terms identified few papers that met the criteria and combined associated terms, identifying a gap in the current research. However, commonality did exist across the searches, indicating that agility is a key PAO for improving sporting performance and injury prevention in athletes (Ishihara, Kuroda, & Mizuno, 2018; Myer, Ford, & Hewett, 2004) and also a foundation for developing children’s PL skills (Whitehead et al., 2012). As such, the concept of agility, as a predictor of successful PL, PA and SI, for school-aged students, is unique and requires further investigation as a precursor to developing more specific learning environments/sporting programs tailored for youth.

1.2. Defining agility—an underestimated predictor for success
Agility has been historically difficult to define (Chelladurai, 1976), with no agreement on a precise definition within the sports science community (Gambetta, 1996; Sheppard & Young, 2006). However, it is often loosely described as the ability to change direction and start and stop quickly (Lloyd, 2015). Much of the difficulty, when attempting to gain a precise and universal definition, comes as a result of the multiple factors in sports science that influence agility performance. However, when exploring the dynamics that make up agility, there is consensus, across the academic community, that it is multifaceted in nature, involving a number of main components and associated sub-components (Figure 1) (Young, James, & Montgomery, 2002). Components, such as perceptual/decision-making factors and the ability to change direction, are seen to compliment and support many of the foundational PL components necessary for developing children’s co-ordination and confidence in PA and SI (Whitehead et al., 2012). Therefore, a new definition of agility was proposed, identifying that, “agility is a rapid whole-body movement with change of velocity or direction in response to a stimulus” (Sheppard & Young, 2006, p.1).

Figure 1. Universal agility components (Young et al., 2002).
However, further research clearly identifies added complexities for determining and measuring agility within larger complex game situations, indicating that agility has relationships with many trainable physical qualities such as technique, strength and power, as well as cognitive components such as visual-scanning, cognitive components and anticipation (Figure 2) (Lloyd, 2015; Lundvall, 2015; Young, 2015). Under each of these qualities, are further important elements that are fundamental to improving children’s PL, being associated with strength, speed, power, body positioning/coordination and recognition of decision-making accuracy.

Given the number of important physical and tactical components evident, literature identifies the complexity and to a large extent the impact positive agility levels have on PL, PA and SI, making for a unique area of study and to a large extent, an underestimated predictor for athletic success. Such findings go to support the need for teachers/coaches to prescribe more wide-ranging holistic learning environments/training programs that promote the dynamic and multifaceted components of agility and address all its contributing elements. Such an approach will not only have impact on creating confidence in students’ PL qualities, but equally important, an impact on successful skill application into games (invasion, net wall, etc.) and wider sporting interests, resulting in heightened PA engagement and SI.

However, the importance of well-developed agility levels, in school-aged children, is unrecognized when it comes to determining and promoting high quality levels of physical competency (PL), engagement in PA and sporting talent identification in youth (Jeffreys, 2011). Inversely, it is well understood that PL, PA levels and SI are important factors in children’s physical, emotional and cognitive development (Usher, 2018; Usher & Curran, 2017; Whitehead et al., 2012). Given the identified gap in the research, it would seem warranted that further research should go to investigate the nexus that exist between improved agility levels and its impact on such domains.

1.3. The nexus between agility, PL, PA and SI

Recently, the Australian Institute of Sport (AIS—Sport Australia) (2016) presented an encompassing definition for PL, which goes to re-enforce this research undertaking, linking the intrinsic components of each domain (PL, PA and SI), by stating,

Physical literacy is lifelong holistic learning acquired and applied in movement and physical activity contexts. It reflects ongoing changes integrating physical, psychological, cognitive and social capabilities. It is vital in helping us lead healthy and fulfilling lives through movement and physical activity.
What is more, there are a number of common, important, identified PL components that impact on a child’s physical competency levels, consisting of four main categories (Tremblay & Lloyd, 2010; Whitehead, 2010; Whitehead et al., 2012), being:

1) **Physical activity behaviours**—directly measurable daily PA levels,
2) **Physical fitness**—such as cardio-respiratory fitness, flexibility, and muscular strength,
3) **Awareness/knowledge and understanding**—how an individual think about physical activity and its importance, and
4) **Motor skills**—refers directly to an individual’s confidence and physical competency, and includes mastery of fundamental movement skills, including agility, balance and coordination.

However, PL and its intrinsic values, throughout PA programs (school/sporting clubs) is poorly executed, or in a state of decline. Okely, Booth, and Patterson (2001) research goes to support such claims, by indicating that historical accounts maintain the proportion of children who displayed mastery of each fundamental movement skill (run, jump, dodge, catch, kick and overhand throw) did not exceed 40%. Given the recorded declining international and national levels of childhood PL, PA (Whitehead et al., 2012) and more recently SI (Roy Morgan Single Source Australia, 2017), it could be suggested that such data trends are becoming increasingly pronounced into the early twenty-first century (Keegan, Keegan, Daley, Ordway, & Edwards, 2013; Parinduri, 2014).

Developing basic skills to move with confidence at an early age is critical, enabling lifelong participation in various physical activities and sports (Whitehead, 2010), with such an ability seen to be supported by heightened agility levels (i.e. avoid opponents, balance, coordination, cognitive). There is also an existing critique, towards making PL an idealistic neutral concept or synonym with fundamental movement skills (agility, balance and coordination) or sports talent identification (Lundvall, 2015; Scanlon, Humphries, Tucker, & Dalbo, 2013). In describing the modern understanding of PL, Whitehead’s (2012) categorisation of movement (simple to complex) aligns with Young et al (2015) identified multifaceted nature of agility (and vice versa), whereby combined movement capabilities enable the development of coordination (bilateral, inter-limb and hand–eye), speed (control of acceleration/deceleration), technical (body awareness, turning/twisting), and decision-making qualities (anticipation, knowledge, visual scanning); all of which are inherent properties of agility.

When reviewing agility in its simplest form (Young et al., 2002), as well as its sophisticated implementation within a game situation (Lloyd, 2015; Lundvall, 2015; Young, 2015), it becomes increasingly evident as to the nexus that positive PL has with increased agility levels (and vice versa), which in turn, would potentially promote sustained engagement in PA and SI.

2. Methods

2.1. Protocol

This study was approved (May 2017) by the Griffith University Ethics Committee (Queensland, Australia). The Department of Education reviewed the project with the centre principal providing final approval for the research. All schools’ and participants’ data were de-identified. Testing and data collection were undertaken at a central testing site (Gold Coast, Queensland, Australia) between June 2017 and April 2018. Participating schools were randomly selected from across South East Queensland (Australia), inviting them to attend a 1-day program, to which students would undertake a series of PAO tests. This research was part of a wider student well-being and leadership program. All staff were qualified teachers and possessed a Blue Card, permitting them to work with children.

Combined parental forms and teacher records collected students’ demographic details to characterise the participants. Before the students attempted the course, parents completed a
permission form to determine whether their child was known to have a medical condition that might be affected by completion of the PAOs. Initially, expert consultations were combined with an environmental scan of PE curricula and published literature/research to determine the appropriate six PAOs included in the testing. It was determined that the PAO tests were synonymous with the basic building blocks of PL and SI for school-aged students (Lovell et al., 2018). The PAO tests were seen as appropriate in their ability to test the hypothesis, as they are fundamental fitness components for successful PL, PA and SI (Lovell et al., 2018; Whitehead, 2010).

2.2. Design
The aim of this research design was chosen to gain insight into a possible, common PAO, that could potentially predict and impact on levels of success associated with PL, PA and SI. A cross-sectional descriptive study was employed, which hypothesised that agility and demographic variables would be predictors of this success, for school-aged students (11–17+ years) across South East Queensland, Australia. Demographic information included collecting participants’ gender, age, year level, height, weight and residential location (postcode). Descriptive statistics were drawn from measuring participants’ performances from six PAOs performed, these being: (1) agility test, (2) vertical leap, (3) broad jump, (4) sit-up test, (5) 10/20/40-m sprints and (6) 12-min run.

Initially, an assessment test design was explored that would evaluate children’s movement skills, as well as their ability to combine simple movement capabilities and perform more complex movement skills in response to a changing environment. A sense of one’s own physical capabilities combined with adept interactions with one’s environment is a foundational concept for PL (Fisher et al., 2005; Whitehead, 2010). For each of the six PAOs, standard performance ranking levels, by age (11–17+) and gender, were provided and were deemed as acceptable performance rankings for school-aged students—performance standards.

2.3. Participants
A total of 234 participants (male = 63.7%, mean age = 13) completed six PAOs. Only 1.3% (N = 3) of the participants identified as Aboriginal Torres Strait Islander (ATSI). Participants were drawn from a number of school districts throughout South East Queensland, Australia. Postcodes recoded students’ SES, with 1 as the lowest and 10 as the highest SES. Participants ranged in age from 11 to 18 years of age, with 13 as the median age and 13.79 as the Mean age. Participants were most likely to be in Year 7 and least likely to be in Year 11. The Median year across participants was Year 8. Participants ranged in height from 143 to 192 cm, with 166 cm as the Median and 166.25 cm as the mean (SD = 10.90 cm) height. They ranged in weight from 40 to 102 kg, with 53 kg as the median and 54.42 kg as the mean weight (SD = 12.62 kg).

2.4. Data collection
Physical activity outcomes included an agility test, vertical leap, broad jump, sit-up test, 10/20/40-m sprints and the distance run in 12 min. Ratings were taken from existing performance data, compiled from performance standards. Each PAO was age and gender specific, to give precise recordings of performances based on the two demographic variables (gender and age) then allocated the predetermined performance scale. Of these tests, agility, vertical jump, broad jump, and the sit-up test could be rated in terms of level of excellence equivalent to five ratings (1 = Poor, 2 = Fair, 3 = Average, 4 = Good, 5 = Excellent), with the 12-min run calculated using Cooper’s Fitness Test, which allows for the conversion of recorded times into 5 age-specific scales, ranging from bad (poor), loose (fair), average, good to excellent. The test to measure the 10/20 m were given approximate ratings of excellence based on the range of available values, then applied to the standardised 40-m measures. The participants performed the jump (vertical and horizontal) and sit up tests from stationary position, with reach height subtracted from leap height to give the extent for the vertical leap.

Each participant was given three attempts at each PAO, with their best performance recorded. All participants performed a standardized dynamic warm-up before testing. The sprints and agility
Tests were measured by a dual beam infrared timing system (Swift Performance Equipment, Lismore, Australia). Each staff member was trained in the processes associated with data collection and recording, ensuring for consistent (validity and reliability) execution of each PAO by each participant. Strict protocols were followed to ensure that each participant completed each PAO under identical conditions. Agility was measured via the Illinosis Agility Test (Figure 3) where the seconds required to get up from a prone position and complete a complex course was recorded.

The validity and reliability of the Illinosis Agility Test is demonstrated via a number of factors, these being: (1) it obtains the same score or near the same score every time, (2) is easy to set up and displays specific measurements, which are hard to deviate from in any manner, (3) can replicate the test to retest an individual, (4) the use sensors that use motion detection to time the individual, (5) to use the same type of surface and (6) portrays validity in that the individual has to stop and go, cut, and move quickly, which are all characteristics of validity. As a measure of agility, in youth, the reliability and validity of the test was 0.98 across three trials (Darren, Gabbett, & Nassis, 2015; Pauole, Madole, Garhammer, Lacourse, & Rozenek, 2000). This proves that it is a highly reliable test. It was shown to measure agility and associated leg power/speed/strength, body co-ordination and positioning and accuracy in decision-making.

2.5. Data analysis

Data analysis was undertaken using Statistical Package for the Social Sciences (SPSS) (PASW20). Data preparation involved the development of one SPSS file to incorporate all PAOs and from the participants’ personal demographic details. The initial data analysis used Frequencies to provide a profile of respondents by variables. The Mean (M) was calculated using SPSS to allow comparison across groups. An analysis of variance (ANOVA) with repeated measures was conducted to determine if the training responses for the experimental groups differed significantly from each other and across each test. In order to assess whether the sample was representative of the population of children of these age ranges (11–17+ years), normative data were used to determine children’s age, gender and body mass index (BMI) percentile scores. A participant’s BMI was determined by their weight (kg) divided by their height (m/cm). Generally, a BMI estimates whether an individual is underweight, healthy weight, overweight or obese, based on their height and weight (Australian Government; National Health and Medical Research Council (NHMRC), 2013). From the determined BMI results, participants were positioned under three categories for analysis, being (1) light, (2) moderate and (3) heavy. Further analysis was undertaken to determine if a participant’s BMI had any significant correlation with PAO.
Pearson correlation coefficients ($r$) were also computed to determine the interrelationships among the tests. The level of significance for both statistical tests was set between $p < 0.05 - p < 0.000$. Associations were reported in terms of the extent to which selected demographic variables correlated and impacted with the level of agility. Structural Equation Modelling (SEM) was further used to demonstrate/test the strength of the relationships between variables in the hypothesis, presenting a visual display for ease of interpretation. Statistical testing ($p < 0.5$, $r$, SEM) was undertaken, for each of the PAOs, to determine if a stronger relationship, other than agility, existed between each activity. Findings indicated that agility was the strongest moderator between all PAO.

3. Results

3.1. Demographic variables
As illustrated in Figure 4, participants ranged in age from 11 to 17+ years of age, with 13 as the median age and 13.79 as the mean age.

As illustrated in Figure 5, participants were most likely to be in Year 7 and least likely to be in Year 11. The median year across participants was Year 8. Participants ranged in height from 143 to 192 cm, with 166 cm as the median and 166.25 cm as the mean ($SD = 10.90$ cm) height. They ranged in weight from 40 to 102 kg, with 53 kg as the median and 54.42 kg as the mean weight ($SD = 12.62$ kg).

As illustrated in Figure 6, postcodes can be recoded in terms of SES, with 1 as the lowest and 10 as the highest SES. The majority of participants were recorded at a middle SES, with few students from the lower or upper SES.

3.2. Physical activity outcomes
As indicated in Table 1, all combined results for each PAO are presented, identifying the percentage (%) and number (N) for each.

3.3. Associations between socio-economic demographic variables and agility
As indicated in Table 2, associations are reported in terms of the extent to which selected demographic variables correlated with agility.
3.4. Associations between PAOs and agility
As indicated in Table 3, associations were reported as to the extent to which selected PAOs correlated with agility.

3.5. SEM test of agility hypothesis
As illustrated in Figure 7, SEM was consistent with the hypothesis that higher levels of agility and being male moderates PAOs. This model fits the data set very well (p < .05, Chi Square/DF < 3, and other fit values in the .95–1.00 region).

4. Discussion
This study hypothesised that higher levels of agility influence the success in a number of fundamental PAOs (i.e. agility, vertical jump, broad jump, sit-up test, 10/20/40-m sprints, 12-min run) and in turn, by demographic variables (gender, height, weight, age, SES). Results indicated that all pathways were positive, and can be summarised as follows: male participants ($r = .208^{**}$, $p < 0.001$), who were
<table>
<thead>
<tr>
<th>PAO</th>
<th>Poor %/N</th>
<th>Fair %/N</th>
<th>Average %/N</th>
<th>Good %/N</th>
<th>Excellent %/N</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agility</td>
<td>11/26</td>
<td>26/67</td>
<td>40/95</td>
<td>61/16</td>
<td>29/16</td>
<td>234</td>
</tr>
<tr>
<td>Broads jump</td>
<td>12/27</td>
<td>23/54</td>
<td>19/45</td>
<td>27/18</td>
<td>23/18</td>
<td>234</td>
</tr>
<tr>
<td>Vertical jump</td>
<td>5/12</td>
<td>13/58</td>
<td>27/78</td>
<td>27/12</td>
<td>19/12</td>
<td>234</td>
</tr>
<tr>
<td>Sit-up</td>
<td>58/18</td>
<td>72/31</td>
<td>26/11</td>
<td>25/8</td>
<td>11/4</td>
<td>234</td>
</tr>
<tr>
<td>12 minute run</td>
<td>31/26</td>
<td>40/24</td>
<td>27/19</td>
<td>27/15</td>
<td>26/15</td>
<td>234</td>
</tr>
<tr>
<td>40m sprint</td>
<td>62/34</td>
<td>74/35</td>
<td>55/55</td>
<td>55/55</td>
<td>55/55</td>
<td>234</td>
</tr>
</tbody>
</table>

N = 315
categorised as light—moderate in BMI ($r = .223^{**}, p < 0.05$), were positively correlated and significantly more likely to be more agile. Participants who were more agile were also significantly more likely to take less time to sprint 10 ($r = .299^{**}, p < 0.051$), 20 ($r = .400^{**}, p < 0.000$), and 40 meters ($r = .400^{**}, p < 0.000$), to leap higher vertically ($r = .312^{**}, p < 0.000$) and further horizontally ($r = .253^{**}, p < 0.051$) and perform more sit-ups ($r = .107^{*}, p < 0.05$).

Table 2. Demographic variables correlations with agility

<table>
<thead>
<tr>
<th>Demographic variables</th>
<th>Spearman’s rho</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SES</td>
<td>-.268^{**}</td>
<td>0.000</td>
</tr>
<tr>
<td>Male participants</td>
<td>.208^{**}</td>
<td>0.001</td>
</tr>
<tr>
<td>Age in years</td>
<td>.019</td>
<td>0.773</td>
</tr>
<tr>
<td>Year level</td>
<td>.061</td>
<td>0.358</td>
</tr>
<tr>
<td>Height in cm</td>
<td>.088</td>
<td>0.182</td>
</tr>
<tr>
<td>BMI (light—moderate)</td>
<td>.223^{**}</td>
<td>0.05</td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).

Table 3. Physical activity outcomes correlations with agility

<table>
<thead>
<tr>
<th>Activity Outcome</th>
<th>Spearman’s rho</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical jump</td>
<td>.312^{**}</td>
<td>0.000</td>
</tr>
<tr>
<td>Broad jump</td>
<td>.253^{**}</td>
<td>0.002</td>
</tr>
<tr>
<td>Sit up</td>
<td>.107^{*}</td>
<td>0.05</td>
</tr>
<tr>
<td>40 metre sprint</td>
<td>.400^{**}</td>
<td>0.000</td>
</tr>
<tr>
<td>12-minute run</td>
<td>.154^{*}</td>
<td>0.020</td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).
In terms of the relative strength of direct versus indirect effects, the strength of the direct effect of gender (male) outweighed that of agility in every instance, consistent with the notion that agility moderates but does not mediate the pathways between demography (gender) and PAOs. This result is not surprising (i.e. males outperform females in PAO), however, given the strength of relationship, it can be concluded that males are more prone to be engaging in PA and SI when compared to females in this study. It is, therefore, a recommendation, from this study, that a more concentrated and coordinated effort is required to bring female students into a more competent ability in PAO. One might conclude that both conceptually and empirically, it makes sense to hypothesise that agility predicts PAOs, either directly or indirectly than to predict that another PAO predicts agility. All single PAOs were individually tested to ensure their relationship and significance as a predictor did not supersede agility. Agility was seen to be the most positive PAO and displayed the most significant one-way directional impact, compared to other potential moderators.

The presentation of results (Table 1) provided a snapshot of students’ physical performances associated with six PAOs. When viewing the combined collected data, pockets of performances can be identified as being categorised into three levels, being: Poor = 315, Fair—Average = 524 and Good—Excellent = 317. Interpretation of such a data trend, concerning PAO results, by participating students, could be seen as needing further investigation, by way of comparisons against other international PAO benchmarks. One noted point of concern was associated with the lower levels of identified sit up test results (Poor = 58%, N = 135) amongst participants. Such sit up tests can be seen as a guide to measuring core strength. The core can be described as a muscular box with the abdominals in the front, paraspinals and gluteals in the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature as the bottom (Richardson, Jull, Hodges, & Hides, 1999). Given that stability and movement (PL) are intrinsically related and critically dependent on the development of core musculature (Stanton, Reaburn, & Humphries, 2004), it would seem warranted that further investigations be undertaken to determine school-aged students’ levels of core strength and if there is need to coordinate interventions. Despite its widespread use, core strengthening has had meagre research and has been hampered by a lack of consensus on how to measure core strength (Arokoski, Valta, Kankaanpaa, & Airaksinen, 2004). However, as this study was concerned with determining the intended hypothesis, such suggested research undertakings, are perhaps seen as a future cross-sectional or longitudinal study.

Findings from this research provide evidence that levels of agility did impact significantly (+) between the relationships, with success in the implemented PAOs moderated by levels of agility and that such variables, as gender and weight, also impacting on PAOs. It is, however, identified, as a limitation to this study, that future research would require a more concentrated effort to attract participants that are more representative of females and varying SES locations. Whilst there is both substantial national and international literature/research recognising trends associated with youths’ levels of PL, PA and SI (Tremblay et al., 2016; Warren, Young, & Henry, 2015) there is, however, limited evidence that goes to explore how agility may be used as a predictor for improving such physical benchmarks in children (Brughelli, Cronin, Levin, & Chaouachi, 2008). Specifically, Vescovi and Mcguigan (2008), posits that much SI and performance literature focuses on performance assessment, with a distinct lack of research examining the relationships between various motor skills, with the examination of correlations between skills proving elusive.

Given the alarming decline in youths’ PL, PA and SI globally (Tremblay et al., 2016; World Health Organization, 2016), there is an urgent need to look for new ways of delivering school-based PE programs and PA learning environments that instil confidence in youths’ fundamental movement patterns and physical capabilities. A recommendation that comes from this research is to further design and implement early years’ programs that are tailored to specifically improve children’s levels of agility, which in turn, will positively impact on many physical performance components necessary for encouraging sustained engagement. Success in encouraging sustained engagement in PA and SI, is primarily due to positive levels of PL (Whitehead et al., 2012), translating to
heightened motivation, confidence, physical competence, knowledge and increased levels of self-efficacy for future engagement for life.

There are, however, criticisms, proposed by Pot and Hilvoorde (2013), maintaining that it may be naive and wishful thinking, that learning the building blocks of movement (PL—i.e. agility), will lead to increased SI. Of importance, is the notion they propose, that sport is often associated with competition between children and/or adolescents, whereas PL is aimed at personal development and realization of individual potential. Yet, contradictorily, they maintain that PL has a very practical approach to SI and development across young people’s lifespan. Nevertheless, there is consensus that components of PL should be approached as a priority and that both educational and the sporting systems can share and as a bridge that can close the gap between PE, PL and SI (Longmuir, 2013; Mandigo, Francis, Lodewyk, & Lopez, 2009). Importantly, correctly designed and implemented PE programs should be the central goal of PL, and accordingly, it will extend to students’ SI context and far beyond. (Pot & Hilvoorde, 2013; Whitehead et al., 2012). What this might look like is perhaps a recommendation for future research.

Revisiting the work of Young et al. (2002), Young (2015), Lundvall (2015) and Lloyd (2015), it is clear that the concept of learning and teaching agility has a great many multifaceted fitness components that contribute to its performance (Figure 2). Therefore, to prescribe a holistic PE curriculum and training program for the development of agility, the teacher/coach can use Young’s (2002, 2015) model as a potential checklist to ensure that all the contributing elements are targeted. However, future research is needed to provide evidence to teachers/coaches about the most important factors and the training methods that are most effective for enhancing agility performance. Interestingly, there is support for the use of small-sided games for improving agility (Darren et al., 2015). This indicates that PE teachers are encouraged and well placed to implement modified games (e.g. invasion, net wall etc.) that specifically promote the physical, technical and cognitive components of games and therefore correspondingly heightening students’ agility levels; a skill that transfers to increased PL and improved PA and SI. Whilst there is conflicting research, surrounding the idea that improving specific fitness components (e.g. speed, strength, power, reactive time) won’t directly improve agility levels (Faber et al., 2016), there is good evidence that the perceptual and decision-making elements are important to agility performance and as such, teaching/training should be prescribed to include these components (Darren et al., 2015).

There are some initial considerations and action steps that could be realistically implemented and would be an achievable goal to ensure the future success of the aforementioned domains (i.e. PL, PA and SI) in Australian schools. The first step in designing and implementing effective PE curriculums, policies and interventions is to understand the current status; much has been ad hoc in its approach to data collection. Although academics, PE teachers, curriculum designers and educational policy makers, have been working in this space for decades, there is still no coordinated, nationwide (Australia) physical fitness testing system, that is specifically designed to capture longitudinal surveillance data associated with school-aged students’ relationships between various motor skills and their potential impact on PL, PA and SI. With this said, most Australian studies involve the use of varied PAO measures; these design deficiencies have made it difficult to present reliable nationwide data concerning levels of PL and SI amongst Australian youth.

While this paper and research is not aimed at presenting training programs that would go to support improved agility levels (that is perhaps for another research endeavour), there appears to be a strong body of evidence that advocates for the inclusion of plyometric training targeted toward pubertal athletes, due to the positive performance impact it has on aspects of agility, namely: power, strength, core stability and speed. Plyometrics is a popular training modality that has been implemented for improving performances in many power sports and has been credited for increasing physical improvements in agility levels. Most plyometric training has used sagittal-plane exercises, but improvements in change-of-direction speed have been greater in multidirectional programs. Similarly, there is strong evidence that neuromuscular training (plyometrics) that selectively
combines several components, not only decreases the potential biomechanical risk factors of lower extremity injury, but also provides performance enhancement effects; all of which go to promote confidence, co-ordination and efficiency in movement (McCormick et al., 2016). As a possible inclusion, into future PE classes, plyometric training programs that emphasise sagittal plane exercises, such as box jumps, repeat hurdle hops, and depth jumps would be seen as important additions. Few studies have examined the effects of plyometric on school-aged students in Australia.

Additionally, there is an urgent need to establish a surveillance system that systematically monitors PL levels, amongst school-aged students and associated behaviours (PA, SI), at the state and national level; making for detailed longitudinal tracking and comparisons across socio-economic demographic variables and specific fundamental motor skills. To achieve this goal, a collaborative, coordinated effort that involves various state and national government authorities is needed. The ability to monitor progress along the lifelong PL journey requires a broad spectrum of valid and reliable methods for charting progress. Centrally designated testing sites, across Australia, with commonly agreed upon testing protocols and PAO measures, would be an initial step in seeing such a goal into fruition. In so doing, it would be possible to substantially reduce the rate of rejection of potential PE curriculum design and PL intervention programs and policy implementation and save resources (time, human, monetary) from being wasted in areas where the data make it clear that a certain demographic group/s would be unlikely to benefit from certain PAO interventions. It would also identify which actions plans associated with PL, PA and SI would be deemed more appropriate to undertake and would facilitate a greater awareness and confidence in individual stakeholders and ultimately allow for a more effective delivery of PE programs in schools and efficient engagement with students across Australia.

5. Conclusion

Whilst this research undertaking identifies a significant and positive relationship between agility, PAOs and specific demographic variables, there are a number of further interesting findings that have presented themselves from this undertaking. It is apparent, that the academic community is divided in the concept that by improving certain fitness components (e.g. speed, strength, balance, co-ordination), this can translate to improved levels of agility, and vice versa. However, it can be argued, that there is consensus as to the importance of improving agility levels, amongst children, so as to positively impact on their gross motor skills, quality of life and social well-being (Amusa & Goon, 2011); with PA and SI seen as essential components of a child’s development (Usher & Curran, 2017). Through the development of perceptual motor skills (i.e. agility), a child is given the practical tools that can be applied to activities inside and outside of the classroom (Del-Busto, 2005).

There is still a great more research needed to explore this concept and to consolidate a universal approach. However, general agreement has been reached, that by improving specific PL components, a student is more likely to value movement and participate in, about and through PE for a lifetime, with improving agility levels seen as a potential starting point for increasing heightened PL, PA and SI in school-aged students. In conclusion, given the notion that agility and demography (gender, weight) moderates the pathways between PAOs, it would be acceptable to suggest, that more attention should be directed towards specifically promoting the inherent benefits of improving school-aged students’ agility levels, with an aim to develop reciprocating positive impacts on their PL, PA and SI.

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Notes
1. The term physical education (PE) is used throughout this paper to indicate class-based physical activity (i.e. acquiring, application and evaluation of movement skills, concepts and strategies to respond
confidently, competently and creatively in a variety of physical activity contexts and settings (Australian Curriculum, Assessment and Reporting Authority (ACARA), 2016).

2 A sagittal plane, or longitudinal plane, is an anatomical plane which divides the body into right and left parts. The plane may be in the center of the body and split it into two halves (mid-sagittal) or away from the midline and split it into unequal parts (para-sagittal).

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