Global levels of fundamental motor skills in children: A systematic review

Lisa E. Bolger[1], Linda A. Bolger[1], Cian O' Neill[1], Edward Coughlan[1], Wesley O'Brien[2], Seán Lacey[3], Con Burns[1], Farid Bardid[4,5]

[1] *Department of Sport, Leisure and Childhood Studies, Cork Institute of Technology, Cork, Ireland*

[2] *School of Education, University College Cork, Cork, Ireland*

[3] *Department of Mathematics, Cork Institute of Technology, Cork, Ireland*

[4] *School of Education, University of Strathclyde, Glasgow, United Kingdom*

[5] *Department of Movement and Sports Sciences, Ghent University, Ghent, Belgium*

Corresponding author: Lisa Bolger

E-mail: lisa.bolger@cit.ie

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Abstract

Competence in fundamental motor skills (FMS) facilitates physical activity participation and is important for children's holistic development. This study aimed to systematically review the FMS levels of children worldwide, using the Test of Gross Motor Development-2 (TGMD-2). In accordance with PRISMA guidelines, prospective studies were identified from searches across 7 databases. Studies were required to: (i) include typically developing children (3-10 years), (ii) be published in English, (iii) have been published between 2004 and 2019 and, (iv) report ≥1 TGMD-2 outcome scores. Extracted data were evaluated based on importance of determinants, strength of evidence, and methodological quality. Data from 64 articles were included. Weighted mean (and standard deviation) scores were calculated for each FMS outcome score. Analyses revealed FMS competence increases across age during childhood, with greater proficiency in locomotor skills than object control skills. Additionally, boys exhibit higher object control skill proficiency than girls. Compared to TGMD-2 normative data, children demonstrate 'below average' to 'average' FMS levels. This review highlights the scope for FMS development among children worldwide. These findings reinforce the necessity for FMS interventions in early educational settings, as FMS competence is positively associated with physical activity and other health outcomes.

Keywords: motor development; motor skills; children; movement skills; physical activity

1 Introduction

Physical activity (PA) is considered an important strategy in addressing childhood obesity.[1,2] One factor underlying participation in PA contexts is motor competence,[3] which represents the degree of proficient performance in a range of motor skills as well as underlying mechanisms such as motor coordination and control.[4] Motor competence can also be reflected by the ability to execute fundamental motor skills (FMS) in a proficient manner, especially during childhood.[4] FMS are basic patterns of movement such as running, jumping and catching.[5] They are commonly referred to as the 'building blocks' or foundation for more complex, context-specific skills.[5] For example, the overarm throw forms the basis for specialised skills such as baseball throw and javelin throw.[6,7] FMS are generally divided into three categories: (i) locomotor skills involving the movement of the body from one location to another (e.g., running and jumping), (ii) object control skills involving the manipulation of an object (e.g., throwing and kicking) and (iii) stability skills involving the acquisition and ability to maintain balance, both static and dynamic (e.g., balancing and twisting).[8] These skills are not acquired naturally[9–11]; rather, they must be learned and developed[11] through quality instruction, practice opportunities and feedback.[11–13]

The early years are highlighted as a critical period in developing and learning FMS; children are expected to have obtained adequate levels of competency in FMS by the age of 7 as they start to engage in physical activities (e.g., sports and dance) requiring more specialised skills.[12] FMS competence is associated with numerous health benefits and is important for the holistic development of children including physical, psychological and overall well-being.[9] Specifically, FMS competence has been shown to be positively associated with higher levels of PA,[14] physical fitness,[9,15,16] cognitive functioning and academic performance.[17] It has also been found to be inversely associated with weight status.[8,9] Furthermore, longitudinal data has revealed that FMS competence tracks through childhood[18,19] into adolescence[20,21] and is a

significant predictor of adolescent PA.[22] Nonetheless, many studies report low levels of FMS among children.[23–31]

As childhood obesity and physical inactivity are serious global health challenges in the 21st century,[32,33] motor competence has received increased interest internationally as a potential mechanism to combat these global problems.[14] Several systematic reviews have been conducted reporting (i) the effectiveness of FMS interventions in improving FMS in youth,[34] (ii) the relationship between FMS and PA in children and adolescents[14] and (iii) the effects of FMS interventions on health outcomes.[35] To date, no study has attempted to collate the FMS levels of children worldwide, to provide a global overview. To enable meaningful comparison of FMS levels between studies, we have selected the Test of Gross Motor Development-2 (TGMD-2). The TGMD-2 is a standardised assessment tool that covers the critical age period of FMS development; additionally, it has been widely used in different countries across the globe.[36] Therefore, the aim of the current study was to conduct a systematic review of FMS levels of typically developing children worldwide (as measured with the TGMD-2).[36]

2 Methods

2.1 Search Strategy

This review was conducted and reported in adherence to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement.[37] Studies were identified by searching electronic databases and scanning reference lists of included articles. Seven electronic databases were searched: Medline [OVID], Sports Discus, ScienceDirect, ERIC, Scopus, PubMed and PsychInfo. The search was limited to studies from January 2004 to examine recent and relevant studies (i.e., over the last 15 years). The last search was conducted on June 12th, 2019. Search terms were divided into 3 different categories: (1) fundamental movement skill*, motor skill*, motor development, movement skill*, (2) child*,

youth, boy*, girl*, schoolchild* and (3) TGMD-2, Test of Gross Motor Development. The Boolean phrase 'AND' was used between categories and the associated phrase 'OR' was used within the phrase in each category.

2.2 Eligibility Criteria

Studies evaluating FMS competence of typically developing children aged 3-10 years, using the TGMD-2 assessment tool (including translated versions), were included. Studies which scored FMS performances either retrospectively (based on video recordings) or live on-site were reviewed. Studies were included if they reported ≥1 of the following outcome measures: raw score (either subtest, in ≥1 skill or total), standard score (subtest or total), gross motor quotient (GMQ), mean percentile (subtest or overall), the percentage of the sample achieving mastery (in ≥1 skill), the proportion of children classified into each of the TGMD-2 performance categories, ranging from very poor to very superior (for locomotor skill, object control skill or overall FMS competence). Only studies that provided numerical data/findings were included (i.e., graphs/charts without numerical labels were not). Study designs included were randomized controlled trials (RCTs) using experimental and quasi-experimental design, observational/cross-sectional studies and pre-post trials. In pre-post design studies and those in which interventions/treatments were administered, only baseline findings were included.

Studies were excluded if they met any of the following criteria: (i) included groups from specific populations (e.g., those with disabilities/disorders, specific sports groups, etc.), (ii) the included sample were reported to solely consist of children from disadvantaged areas or low socioeconomic status, (iii) only outcome scores post-intervention reported, (iv) some/all of the data from the sample included were also reported as part of other included studies, (iv) not published in a peer-reviewed journal, (iv) not published in English, (v) published in book chapters, case studies, dissertations, conference abstracts, review articles, meta-analyses, systematic reviews, protocol papers or editorials, and (vi) full-text was not available.

2.3 Outcome Measures – TGMD-2

The TGMD-2 is a process-oriented FMS assessment tool. Normative sample data is provided in the TGMD-2, which was collected from 1208 children from 10 states in the United States between 1997 and 1998.[36] This facilitates the comparison of FMS competence to a standardisation sample.

The TGMD-2 consists of 12 FMS, divided into two subtests of skills; locomotor and object control skills. The six locomotor skills consist of running, galloping, sliding, leaping, hopping, and horizontal jump. The six object control skills are kick, catch, overhand throw, strike, underhand roll, and dribble.[36] The TGMD-2 has been found to be valid and reliable among children aged 3-10 years[36,38–40]. Content validity was established qualitatively, based on unanimous agreement of three content experts who declare the skills as representative of those taught to the specified age group and also quantitatively, using discrimination and item difficulty statistics. Criterion-prediction validity of the TGMD-2 is reported, with a strong to moderate correlation between TGMD-2 subtests and criterion variable (ranging from 0.43-0.63). Construct validity has also been established.[36] Internal consistency among items was found to be good-to-excellent with Cronbach's alpha coefficients of 0.85 (locomotor subtest), 0.88 (object control subtest) and 0.91 (GMQ).[36] The TGMD-2 also has high test-retest reliability (ranging from 0.88-0.93) and inter-rater reliability (0.98 for all) across subtests and GMQ.[36]

In this assessment tool, children perform one familiarisation trial and two test trials. Each of the 12 FMS consist of 3-5 behavioural components. If a component is performed correctly, a score of 1 is awarded. If the behavioural component is performed incorrectly, a score of 0 is awarded. This procedure is repeated for each component of a skill across the two test trials. Scores from both trials are summed to obtain a raw skill score.[36] 'Mastery' of an FMS is

achieved when all components of a skill are present (i.e., skill performed correctly) across both test trials.

Locomotor and object control subtest scores are calculated by summing the raw scores of the individual skills within each subtest (Locomotor Score Range: 0-48; Object control Score Range: 0-48). Based on the normative data tables in the TGMD-2 manual, subtest scores are converted to standard scores (LMSS and OCSS, range: 1-20) adjusted for age (locomotor and object control subtest) and sex (object control subtest).[36] Following, the LMSS and OCSS score are summed and converted to an overall standard score or Gross Motor Quotient (GMQ; range: 48-160). LMSS, OCSS and GMQ can be used to categorise the locomotor, object control and overall FMS performance of each child into one of 7 categories, ranging from very poor to very superior.[36]

TGMD-2 data can also be used to derive mean percentiles and age equivalents. Mean percentiles, or percentile rank, represent the proportion of the normative sample who achieved a value equal to or below the associated score. For example, a percentile of 60 means that 60% of the normative sample scored less than or equal to the performer's score. Age equivalents use subtest scores to provide an estimated developmental age based on a child's performance.[36]

2.4 Study Selection

Following the systematic search, 2 reviewers (XXX and XXX) independently removed all duplicates and the title and abstract of the remaining retrieved files were screened. Any disagreements were resolved by reviewing articles together and thorough discussion. Full-text articles were retrieved for the remaining files and independently screened by both reviewers for inclusion criteria, using a 'yes, no or maybe' approach.[41] Level of agreement was found to be 92%. Conflicting decisions (i.e., files assigned 'maybe') were jointly reviewed together and discussed until consensus was reached on all files.

2.4.1 Overview of Studies

Fig. 1 displays the PRISMA flowchart of studies through the review process. The search strategy identified 908 records. After removing duplicates (n=76) and screening of titles and abstracts (n=700), 132 articles were retrieved. Of these, 64 fulfilled the inclusion criteria and were included.

2.5 Quality Assessment of Included Studies

Study quality was independently assessed by 2 reviewers (XXX and XXX) using the Study Quality Assessment Tools developed by the National Heart, Lung and Blood Institute (NHLBI).[42] Three appropriate tools were used: (i) Quality Assessment of Controlled Intervention Studies, (ii) Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies and (iii) Quality Assessment Tool for Before-After (Pre-Post) Studies With No Control Group (Table S1-S3). Each item on the scale was coded as '1' (Yes), '0' (No), 'CD' (cannot determine), 'NR' (not reported) or 'NA' (not applicable). Each item was individually considered, as recommended by the PRISMA statement.[37] Inter-rater reliability between reviewers was calculated, with >85% agreement established across all 932 items. Following this review process, articles in which disagreements were found were further reviewed by both assessors together and following discussion, consensus was reached. A quality score (as a percentage of applicable criteria) was calculated for each study. Studies that scored greater than 67% were classified as high quality, studies that scored 34-67% were classified as medium quality and those that scored 33% or less were regarded as low quality. 23 studies were rated as high quality,[25,43–64] 39 were identified as medium quality,[11,23,28,31,38,40,65–97] and two were classified as low quality[98,99] (Table S1-S3). All studies were considered for analysis.

2.6 Data Extraction

The following data were independently extracted by two reviewers (XXX and XXX) using an Excel template developed by both reviewers: (i) author and year of publication, (ii) research design and setting, (iii) participant characteristics (including age, sex, country, sample size, specifics of population group), (iv) the number of FMS assessed and administration protocol used (i.e., individually or in groups), (v) FMS scoring protocol (including live/retrospective scoring, inter-/intra-rater reliability) and (vi) type of outcome measure reported (raw skill/subtest scores, standard score, GMQ, percentage achieving mastery in each skill, age equivalent score, mean percentile). Data extracted independently by both reviewers were compared, with 100% agreement found.

2.7 Data and Statistical Analyses

Data (excluding actual FMS outcome scores) were first collated and described in a narrative summary. FMS outcome scores (i.e. FMS levels) from each study were quantitatively reported (in the form of raw scores, standard scores, age equivalent, mean percentiles, percentage achieving mastery in each skill or percentage categorised across TGMD-2 categories.

Mean and standard deviation of each FMS score reported in each study were included. As evidence reveals older children tend to exhibit higher levels of FMS than younger children,[23,25,26,31,45] FMS outcome scores were collated for each individual age ranging from 3-10 years of age and also the following age ranges: (i) 3-5 years, (ii) 6-8 years, (iii) 9-10 years, and (iv) 3-10 years. These age ranges represent typical preschool age (3-5 years), early-middle childhood (6-8 years), and middle childhood (9-10 years).[100] The 3-10 year age range represents the ages across which the TGMD-2 has been reported to be valid and reliable.[36] In studies including children between the ages of 3 and 10 years of age as well as older, only data relating to children between 3-10 years are included in the analyses.

For each group, weighted mean and standard deviation scores were calculated for raw FMS scores (skill, subtest and total), standardised scores (GMQ, SS) and percentile scores (subtest and overall rank) using the following formulae[101]:

Weighted mean $(\overline{x_w})$ = $\frac{\sum(w_i * x_i)}{\sum w_i}$

Weighted standard deviation (sd_w) = $\sqrt{\frac{\sum_{i=1}^{N} w_i(x_i - \overline{x_w})^2}{\frac{(N'-1)\sum_{i=1}^{N} w_i}{N'}}}$

where w_i is the weight of the i^{th} observation (i.e. sample size), x_i is the mean score of the i^{th} observation, N' is the number of non-zero weights.

The weighted proportion of children achieving mastery and the proportion of children in each of the TGMD-2 categories (for LM, OC and overall FMS) were calculated using the following equation:

Weighted frequency = $\frac{\sum_{i=1}^{N} Frenquency_i}{\sum n}$

where $frequency_i$ is the number of children achieving mastery (or present in a category) in the i^{th} observation and n is the sample size.

3 Results

3.1 Study Characteristics

Table 1 presents the selected characteristics of eligible studies included in this review. Forty-two studies were published between 2015 and 2019,[23,25,43–45,47,49,50,52,54,55,57,61,63–66,68–76,79–86,90,92–94,96–99] nineteen between 2010 and 2014[28,31,38,40,46,48,51,53,56,58–60,67,77,78,88,89,91,95] and three between 2005 and 2009.[11,62,87] Studies selected for inclusion were drawn from 25 different

countries across six continents. Ten studies were carried out in the United States,[51,59,68,71,74,77,78,80,89,92] nine in Australia,[46,49,52,57,58,62,83,84,97] six in China,[11,40,56,66,67,87] five in Brazil, [31,47,53,64,86] four in Canada[48,63,70,90] and the Czech Republic,[50,60,82,96] three in Portugal,[43,45,69] Iran [28,73,91] and South Africa,[44,81,85] two in Taiwan[55,76] and one in Ireland,[25] Belgium,[23] Britain,[72] Chile,[65] Croatia,[88] Indonesia,[95] Italy,[99] Japan,[94] Myanmar,[54] Poland,[75] Scotland,[93] Spain,[98] Singapore,[79] South Korea,[38] and one in the United Kingdom.[61] The majority of studies (34 of 64: 53%) involved the evaluation of FMS of children recruited from a primary school setting.[11,25,43–45,49,52,53,56,57,59–61,63,65,66,70,73,75,76,78,79,81,83,84,86,88,91,93,95–99] Twelve studies recruited from preschools,[46,47,50,51,55,62,67,77,80,82,85,89] three recruited from kindergartens,[48,54,94] two separate studies outlined that they recruited from kindergartens and YMCA,[40,87] and two studies recruited from childcare centres.[90,92] One study recruited from 51 child settings including sports clubs, local councils, school and day-care centres.[23] One study recruited from a municipal school,[64] one from public schools as well as day-care centres,[31] one from schools and preschools,[72] and one from a nursery school.[28] Another recruited by distributing flyers to the local school district, at professional meetings and given to friends of participants.[71] One study included children who completed the CDC/NHANES National Youth Fitness Survey,[74] one recruited children from preschools as well as childcare centres[58] while one study recruited children from an urban school district in Ohio, a rural school in Texas and a before and after school program in Michigan.[68] The setting from which children were recruited was not detailed in two studies.[38,69]

There were 50 cross-sectional design studies,[11,23,49,50,52–55,58–61,25,62,64–72,31,73–82,40,83,85–87,89,94–97,99,43–46,48] eight quasi-experimental studies,[28,51,56,84,91–93,98] two RCTs,[57,90] two longitudinal studies,[47,63] one validity and reliability study,[38] and one study which was a construction and validation of a new FMS tool.[88] The sample sizes for the studies ranged from 14[51] to 2674 children.[86] Nineteen had a sample size <100.[50,51,58,61,62,64,65,71,75,77,78,80,88–92,94,95] Fourteen studies

had a sample size between 100-199 children[11,28,38,43,49,52,53,57,59,72,83,93,97,99] while 31 had a sample size ≥200.[23,25,31,40,44–48,54–56,60,63,66–70,73,74,76,79,82,84–87,96,98] Two studies included girls only,[73,91] while the remaining studies were co-educational.

3.2 Measurement of FMS

Fifty-five studies tested all 12 skills of the TGMD-2,[11,23,25,28,31,38,40,43,45,47–55,58,60–68,70–80,82–91,93–96,98,99] four studies tested the 6 OC skills only,[44,81,92,97] one study examined four OC skills only (throw, catch, kick, strike),[59] one study examined three OC skills (throw, catch, kick),[57] one study examined 8 FMS (run, gallop, hop, jump, strike, catch, kick, throw),[46] one study solely examined the throw[56] and one study solely examined the kick.[69] Twenty-six studies did not report whether FMS performances were scored/coded live or retrospectively using video recordings.[28,43–45,47,49,50,52,60,61,68,69,74,81,82,84,88,90–93,95,96,98,99] Of the 39 studies which did specify, 30 coded FMS performances retrospectively only[11,25,31,38,48,51,53–55,57,62–65,67,70–73,76–80,83,85–87,89,94] while seven coded assessments live on site only.[23,46,56,58,66,75,97] One study coded assessments both live and retrospectively[40]. The number of individuals who scored or coded the FMS performances of participants (i.e. coders) ranged from one[11,51,57,62,63,67,70,77,87,89] to eight.[66] The use of two coders was the most commonly reported scoring protocol selected,[25,31,47–49,59,61,64,65,71–73,78,81,83–85,90,97] while seven studies used three coders[38,53,54,75,80,86,92] and five studies used four coders.[40,55,56,58,76] The remaining 22 studies did not report the number of coders used.[23,28,43–46,50,52,60,68,69,74,79,82,88,91,93–96,98,99] In ten of the studies, assessments were conducted individually.[43,46,53–55,62,64,68,71,86] Thirteen studies conducted the assessments in groups, ranging from 2-10 children,[25,40,48,49,63,65,66,70,78,83–85,94] while the majority (n=41) did not specify.[11,23,28,31,38,44,45,47,50–52,56–61,69,72–77,79–82,87–93,95–99]

3.3 FMS Outcomes

Raw scores (skill scores and subtest scores) were the most reported type of FMS outcome, with 41 studies reporting OC subtest score,[11,23,25,28,38,43,45,46,48,49,52,54,55,58,60,62,63,65–67,70,72–76,79,80,82–84,86,87,89,92,94–99] 39 reporting LM subtest score,[11,23,25,28,38,43,45,46,48,49,52,54,55,58,60,62,63,65–67,70,72–76,79,80,82–84,86,87,89,94–96,98,99] (Table 2) and 18 reporting individual raw skills scores[23,38,40,43–46,54–57,63,75,76,80,81,86,94] (Table 3). Raw total FMS score was less commonly reported, which was included in 12 studies[46,48,49,53,55,67,72,76,79,88,96,99] (Table 2). Standardised scores based on age and sex, including GMQ[11,23,25,28,50,54,62,71,73,78,79,82,90,93,94,96] and OC SS[11,23,28,47,54,62,71,74,78,79,81,90–94] were reported by 16 studies, while LMSS were reported by 14 studies[11,23,28,47,54,62,71,74,78,79,90,91,93,94] (Table 4). Total SS (which is subsequently used to calculate GMQ) was reported in four studies[11,28,54,94] (Table 4).

Ten studies reported GMQ percentile (overall percentile rank)[11,51,64,68,77–79,90,91,93], 14 reported mean OC percentile,[11,51,54,60,61,64,67,77,79,81,90,92–94] and 12 studies reported mean LM percentile.[11,51,54,60,61,64,67,77,79,90,93,94] Kordi et al[28], Mukherjee et al[79], Spessato et al[31], and Pang and Fong[11] reported age equivalent scores for both LM and OC skills, while Pineaar et al[81] reported mean OC percentile only (Table 4). The proportion of children classified into the seven TGMD-2 categories was reported in three studies for LM,[11,23,74] four studies for OC,[11,23,74,81] and 10 studies for GMQ[11,23,28,53,54,79,82,85,94,96] (Table 5). The mastery levels (percentage of children achieving mastery) in each of the 12 FMS were reported by six studies[25,46,59,69,79,87] (Table 6).

3.4 Raw Subtest and Total FMS Scores

3.4.1 Age differences

Table 7 presents weighted mean and standard deviation scores based on all studies that have included raw scores (skill, subtest, and total), standardised scores (subtest and GMQ) or mean percentiles (subtest and GMQ) across the individual age groups and age ranges. The weighted

mean raw LM subtest score increased with age, with the exception of a lower score among 9-year-olds compared with both the 7- and 8-year-old cohorts. Similarly, the weighted mean raw OC subtest score increased across the age groups with the exception of the 9-year-old group which had a lower mean OC subtest score than the preceding age group (see Fig. 2). The weighted mean raw LM subtest score ranged from 20.1 (42% of maximum) for 3-year-olds to 37.1 (77% of maximum possible score) for 10-year-olds. Raw OC subtest score ranged from 15.6 (33% of maximum possible score) for 3-year-olds to 35.2 (73% of maximum score possible) for 10-year-olds. The weighted mean raw Total FMS score increased with age (see Fig. 3), ranging from 37.2 (39% of maximum possible score) among 3-year-olds to 76.5 (80% of maximum possible score) among 10-year-olds.

Across all studies reporting raw subtest scores (3-10 years), the weighted mean scores for LM and OC were 32.1 (67% of maximum possible score) and 27.9 (58%), respectively. All weighted mean LM subtest scores in each of the age groups and age ranges were higher than the respective OC subtest score (see Fig. 2).

3.4.2 Sex differences

Table 8 presents weighted mean and standard deviation scores based on all studies that have included raw scores (skill, subtest, and total), standardised scores (subtest and GMQ) or mean percentiles (subtest and GMQ) for both males and females across each age range. For LM Score, the weighted mean difference between boys and girls was less than 1 unit (weighted mean difference range: 0.7-0.9). Overall, and for the age ranges 3-5 and 6-8 years, girls achieved a slightly greater score than their male counterparts (weighted mean difference range: 0.7–0.8). In contrast, for the 9-10 age range, boys achieved a slightly greater LM score (weighted mean difference: 0.9) than girls of similar age (see Fig. 4).

Based on weighted mean OC score, the boys at each age range (3-5, 6-8, 9-10 years and overall) exhibit higher levels of OC skills than their female counterparts (weighted mean

difference range: 3.2 among the 3-5 year old group, 4.5 among the 6-8 year old group, 6.1 among the 9-10 year old group and 4.1 between boys and girls overall) (see Fig. 4).

For overall FMS competence, the boys at each age range (3-5 years, 6-8 years and overall) exhibit a slightly higher weighted mean total FMS score than their female counterparts (weighted mean difference range: 0.8 among the 3-5 year old group, 4.3 among the 6-8 year old group, and 2.3 between boys and girls overall) (see Fig. 4). No included studies reported the total FMS score stratified by sex for 9 or 10 years of age (9-10 age range).

3.5 Gross Motor Quotient and Standard Scores

3.5.1 Age differences

GMQ, LMSS and OCSS, which are standardised scores based on age and sex, are a valuable measure of FMS competence as they allow skill levels to be directly compared across children. The weighted mean GMQ ranged from 83.0 (9-year-olds) to 104.2 (5-year-olds). According to TGMD-2 descriptive rating categories (ranging from very poor to very superior), all age groups from the 3-year-olds up to the 8-year-olds, as well as both the 3-5 year old age range and overall sample are classified as 'average' (range: 90-110) for overall FMS competence. Lower FMS competence is evident among both the 9- and 10- year-olds, as well as the 6-8 and 9-10 year old age ranges with a weighted mean GMQ score in the 'below average' classification (range: 80-89) (Table 7).

The weighted mean LMSS ranged from 6.5 (9-year-olds) to 11.5 (5-year-olds) and the weighted mean OCSS ranged from 6.5 (9-year-olds) to 9.4 (5-year-olds). According to the TGMD-2 SS classifications, the weighted mean LMSS of the 9-year-olds (6.5) as well as the as the 9-10 year old age range (6.5) are classified as 'below average' (range: 6-7), with all remaining age groups (3y, 4y, 5y, 6y, 7y, 8y) and age ranges classified as 'average' (range: 8-12). For weighted mean OCSS, the individuals age groups from the 3-year-olds up to and including the 7-year-olds, as well as all age ranges (3-5 years, 6-8 years, 9-10 years, overall)

are categorised as ‘average’ (range: 8-12). Lower levels of OC skills were observed among both the 8- and 9-year-olds, with weighted mean OCSS for the respective groups categorised as ‘below average’ (range: 6-7). No included studies reported LMSS or OCSS among 10-year-olds.

3.5.2 Sex differences

Among both the 3-5 year old age range and the overall cohort of children (3-10 years), both the boys and girls are classified as ‘average’ (GMQ range: 90-110) for overall FMS competence (Table 8). Similarly, among the 9-10 year old cohort, both the boys and girls are classified in the same category, ‘below average’ (range: 80-89). In contrast, among the 6-8 year old age range, boys are classified as ‘average’ (GMQ: 92.9), while the girls are classified as ‘below average (GMQ: 86.5).

Among the 3-5 year old and 6-8 year old age ranges as well as the overall cohort of children, the weighted mean LMSS indicate that both the boys and girls have ‘average’ levels of LM skills (range: 8-12). Among the 9-10 year old age range, the weighted mean LMSS indicate that the cohort of both the boys and girls demonstrate similar locomotor ability, classified as ‘below average’ (range: 6-7). Based on OCSS, both the boys’ and the girls’ cohorts at each of the respective age ranges are classified as ‘average’ (range: 8-12).

3.6 TGMD-2 Performance Categories

Children were individually classified across the TGMD-2 descriptive ratings for LMSS, OCSS and GMQ (ranging from very poor to superior) in 14 studies (Table 5). The weighted proportion across each category (Table 9) indicated that the greatest proportion of children (within each of the age ranges: 3-5 years, 6-8 years, 9-10 years, and overall) were classified as ‘average’ for LMSS (57-64%), OCSS (51-69%) and GMQ (34-49%). respectively. For LMSS, OCSS, and GMQ, the smallest proportion of children were categorised at either end of the continuum with ≤5% of children classified as either ‘very poor’ and ‘very superior’, with the

exception of the 6-8 year old age range in which 6.3% were categorised as 'very poor' for OCSS. Interestingly, for OCSS across all age ranges, no children were categorised as 'very superior'. When compared with the TGMD-2 normative sample (US reference sample), despite a larger proportion of the current sample classified as 'average' for both LMSS and OCSS, a lower proportion are classified into the categories on the right of the continuum (i.e., in the 'above average', 'superior' and 'very superior' categories). Furthermore, a larger proportion of the current sample are classified as 'poor' and 'below average' for OCSS compared with the normative sample (Fig. 5). The proportion of children classified into each of the TGMD-2 categories based on GMQ score are similar among the current sample and the US reference sample, with the exceptions of a higher proportion of the current sample classified as 'poor' and a lower proportion classified as 'above average' (Fig. 5).

3.7 Mastery Levels

The proportion of children achieving mastery (i.e., mastery levels) in each of the skills assessed were reported in six studies (Table 6). The weighted frequencies of mastery levels (%) based on the assessment of 405-2786 children (when sample data from all six studies were combined together) are presented in Table 10.

The skill with the highest proportion of children achieving mastery was the run, across all age ranges (ranging from 54% of the 3-5 year olds to 85% of 9-10 year olds). Another locomotor skill, the gallop, was the 2nd most proficient skill for all age ranges (range: 47-74%) with the exception of the 3-5 year old age range in which it was the 4th most proficient (26%) after the run, leap, and jump. The leap was also among the top 3 most proficient skills across all age ranges (range: 33-67%). The skill with the lowest proportion achieving mastery was the roll across all age ranges (range: 1-14%). Another object control skill, the throw, was among the three least proficient skills across all age categories, ranging from 6-7% among the 3-5 year old and 6-8 year old age ranges to 20% among the 9-10 year old age range. The hop was the

least proficient locomotor skill across all the age ranges (range: 10-19%). It was also among the three least proficient skills across the 6-8, 9-10, and 3-10 year old age ranges.

4 Discussion

This systematic review has examined the FMS levels of children worldwide using the TGMD-2. It provides a collation of FMS levels of over 21000 children, from 25 countries and six continents. Analysis produced mean scores (raw scores, standard scores, GMQ and percentiles) across all relevant studies representing the FMS levels of each respective age group (3-10 years) as well as representing the levels of children of preschool age (3-5 years), early-middle childhood (6-8 years), middle childhood (9-10 years) and for the age range across which the TGMD-2 assessment tool is valid and reliable (3-10 years).

Both age and sex have been found to influence FMS proficiency among children.[6,102] Existing trends revealed in the current review highlight that children's FMS levels tend to be higher among older children in comparison to the younger ages. This may result from a combination of maturation and additional quality FMS instruction, feedback as well as practice opportunities, during the additional life years.[103] At each respective age (and age range), children exhibited higher levels of LM skills compared to OC skills. When classified according to TGMD-2 performance categories, no child exhibited 'very superior' levels of OC skills. Furthermore, the throw and roll (both object control skills) were found to be among the least proficient skills across all age groups and ranges. This supports the suggestion that greater instruction and practice are needed for object control skills than locomotor skills due to the greater perceptual demand and complexity of the object control skill components.[34]

Developed in the US, the TGMD-2 includes skills such as strike and throw which may be more relevant in a US sports context than other countries (as these skills are associated with baseball, basketball and American football which are among the most popular sports in the

US).[104] Cultural differences may therefore have an influential role on FMS competence among children. As illustrated in Fig. S1, 3-5 year-old children from non-US samples seem to score lower on OC skills compared to the US reference sample (but similar on LM skills). However, this is not the case for older age groups as 6-10 year-old children from non-US samples seem to score lower on both OC and LM skills (Fig. S1). These lower FMS levels relative to the TGMD-2 normative data (based on data collected from a sample of 1208 US children in 1997-1998) may then also be due to a secular downward trend in FMS competence and physical activity.[105] More research adopting recent norms is needed to distinguish the impact of cultural differences from secular trends.

This review also found sex-related differences in FMS levels. While similar competence levels in LM skills appear to exist between boys and girls, boys tend to outperform their female counterparts in object-control skills. Similar to the present findings, the systematic review and meta-analysis of Barnett et al.[102] found sex to be a strong correlate of OC skills (with boys being more competent) but not of stability or LM skills. These differences could be considered from a biological viewpoint although boys and girls tend to possess similar physical characteristics such as body type, strength and limb lengths prior to puberty.[106] It is then likely that sex differences are explained by the type of activities that children participate in. Previous research has suggested that the activities that boys and girls engage in are largely influenced by social and environmental factors such as the influence of family, peers, teachers, and the physical environment,[6,46,107] with boys participating more in ball sports (object-control related activities) while girls participate more in dance and gymnastics (locomotor related activities).[23,46,107,108] This highlights the need for increased attention on developing girls' OC skills, especially as object-control skill competence during childhood is positively linked with PA during adolescence.[22] A recent family-based intervention study by Morgan et al.[109] has shown that preadolescent girls' proficiency in OC skills can be improved and sustained.

According to TGMD-2 classifications,[36] overall standardised FMS performance based on age and sex (weighted GMQ) indicates that 3-5 year old children worldwide demonstrate 'average' FMS levels while 6-8 and 9-10 year old children demonstrate 'below average' FMS levels. As GMQ is derived based on age (and sex), and while the youngest age range (3-5 year olds) exhibited 'average' FMS levels, children from 6-10 years old may not have received the quality instruction and feedback or opportunities for FMS practice to improve their FMS levels, relative to the increase in age. The secular decline in PA among children worldwide in recent times [110–112] must also be considered as a contributing factor to the FMS levels among children. The findings revealed in this review highlight the large potential for FMS development among children of all ages.

To improve FMS levels among children, (i) quality instruction in teaching the skills,[29,113] (ii) practice time undertaken by children and (iii) feedback are all essential elements.[5] Both the age and sex differences highlighted within this review highlight the need for these elements to be provided for children to develop skills from both sub categories (locomotor and object-control) during PE, extra-curricular activity, and free play from teachers, parents, and peers.[25,31] Recent systematic reviews on the effectiveness of FMS interventions among youth populations revealed that such intervention programs have the potential to significantly improve FMS levels in this cohort.[34,114] A large effect size for overall FMS (1.42) and locomotor skill (1.42) competence were reported following such interventions, with a medium effect size (0.63) reported for object-control skill competence.[34] As children have the potential to master FMS by the age of 5-7,[5] and have been shown to improve FMS greatly at a young age,[29] it is important that all proposed interventions are introduced as early as possible. Thus, based on the current worldwide levels which indicate the potential scope for improvement, FMS interventions that have been found to improve FMS greatly at a young

age[29] should be implemented in early education settings, including primary schools, to enhance the FMS levels of children.

The school setting offers an ideal opportunity for the development of FMS, with physical education identified as one of the most influential factors.[115] During the primary school years, children spend approximately 40% of their waking day in the school setting, throughout the academic year. In addition, primary schools often possess the necessary resources (including teachers but also facilities and equipment), scope within the physical education curriculum and access to all attending children to facilitate FMS development.[116,117] As quality instruction, practice opportunities and feedback are essential elements for FMS development, FMS knowledge and education are imperative for the teachers, club coaches, parents and significant others, with research indicating extensive FMS training and support for teachers/coaches can positively impact FMS levels of children.[29,118]

It is reported that motor skill interventions most consistently associated with improvements in FMS include those adopting a multi-disciplinary approach, of long duration (>6 months), providing multiple sessions per week, delivered by trained individuals (e.g., physical education specialist) and supported by parental involvement (e.g., 'at home' practice assisted or supervised by parents, parent evenings).[35] The introduction of after-school (or alternatively lunchtime or before school) multi-skills clubs has also been found to be effective in improving FMS[114] in addition to those involving community engagement.[119,120] Based on the evidence presented in this review that highlights the substantial scope for improvement in FMS competence levels, interventions incorporating these aforementioned approaches may be required to develop these motor skills. It should be noted that, whilst motor skill interventions may have long-term effects on children's FMS,[121] there is currently limited evidence on the sustained impact of such interventions.[122] Therefore, future intervention research should

include long-term follow-up evaluations, in order to better understand if and how programmes are achieving sustained effects on FMS.

Given the existent reciprocal relationship between FMS and PA[123] and the associated health benefits (physical, psychological and social) [9], this review serves to provide a valuable insight, and may guide education and health authorities, in developing policies and strategies to improve PA and sport participation levels as well as the overall health and well-being of children. With physical inactivity identified as the fourth leading risk factor for global mortality,[124] any improvement in the FMS levels of children may help increase PA levels and thus ease the global physical inactivity crisis.[125] An increase in FMS competence may also combat the rise in overweight/obesity levels worldwide, which have dramatically increased from 4% in 1975 to over 18% (340 million) in 2016 among children and adolescents.[126]

4.1 Future Recommendations

For all future research, it is recommended that standardised scores (subtest and GMQ) and raw skill scores must be reported when FMS levels using the TGMD-2 are presented to allow comparisons across studies. As is evident in the current review, studies that did not report some or all of the respective scores could not be used for comparison with studies that did. The reporting of standardised scores are recommended as per the guidelines of Ulrich[36]; they provide the clearest indication of FMS competence (locomotor, object control or overall), accounting for age and sex. However, norm tables (based on 1997-1998 sample) can be considered outdated or skewed to some cultures. Thus, the development of more up-to-date norm tables based on a larger sample across a wider geographical area is also recommended. It should be noted that a third version of the Test of Gross Motor Development (TGMD-3) has been developed with new norms.[127] The reporting of raw scores (subtest and skill) are also important as they provide information relating to proficiency in each of the individual skills, which may highlight specific skills that may require specific attention. Specifically, raw scores

allow us to support boys and girls in developing the most proficient patterns of performance for both LM and OC skills.

A further recommendation is the introduction of periodical formal assessment of FMS competence among children of all preschool and primary school ages to monitor the development of children's motor skills. This will further assist teachers as well as education and health authorities in the attempt to facilitate the holistic development of each child. Furthermore, it will add to the existing body of cross-cultural research on motor competence[105,128–130] and provide accurate comparisons of FMS levels to be made across different ages and countries. Contextual factors should also be considered in order to better understand and support FMS levels of children. One such factor is socioeconomic status, which is shown to be positively associated with FMS levels.[102] Moreover, children from disadvantaged backgrounds may be more at risk for delays in FMS due to limited opportunities to PA participation, and may therefore benefit from targeted motor skill interventions.[131,132] Finally, longitudinal research and long-term follow-up studies are recommended to establish trends and patterns in FMS development and inform policy and practice.

4.2 Strengths and Limitations

Strengths of this review include: (i) the use of a comprehensive search strategy across several databases, (ii) an extensive study detail extraction, (iii) an alignment with the PRISMA statement and (iv) the inclusion of FMS levels across 25 different countries. Limitations include: (i) focus on studies that used the TGMD-2 as a measurement tool, (ii) only studies published in English were included, (iii) studies including participants from low SES, as well as from special populations (e.g., children with disabilities/disorders, volleyball players) were not included and (iv) a relatively small sample size was used in the calculation of several weighted mean scores due to the limited number of studies reporting the respective scores. While the current systematic literature review collated data from children worldwide, further

research is needed to examine differences in FMS competence between specific countries, continents, or similar geographical location.

5 Conclusion

Raw scores (weighted mean scores) indicate that fundamental motor skill levels are greater among older children than younger children. Based on standardised scores, SS and GMQ (weighted mean scores), children of preschool age worldwide (3-5 years) demonstrate 'average' FMS levels, while children aged 6-10 years demonstrate 'below average' FMS levels when compared with normative data collected in 1997-1998, presented in the TGMD-2 manual.[36] Evidently, children worldwide are not achieving proficiency in these basic motor skills, despite the expectation that they should achieve adequate competence levels by the age of 7 in order to participate successfully in sports, games and other physical activity forms that require more context-specific skills. Evidence reveals the large opportunity and scope for improvement in all FMS, among all age groups, remains.

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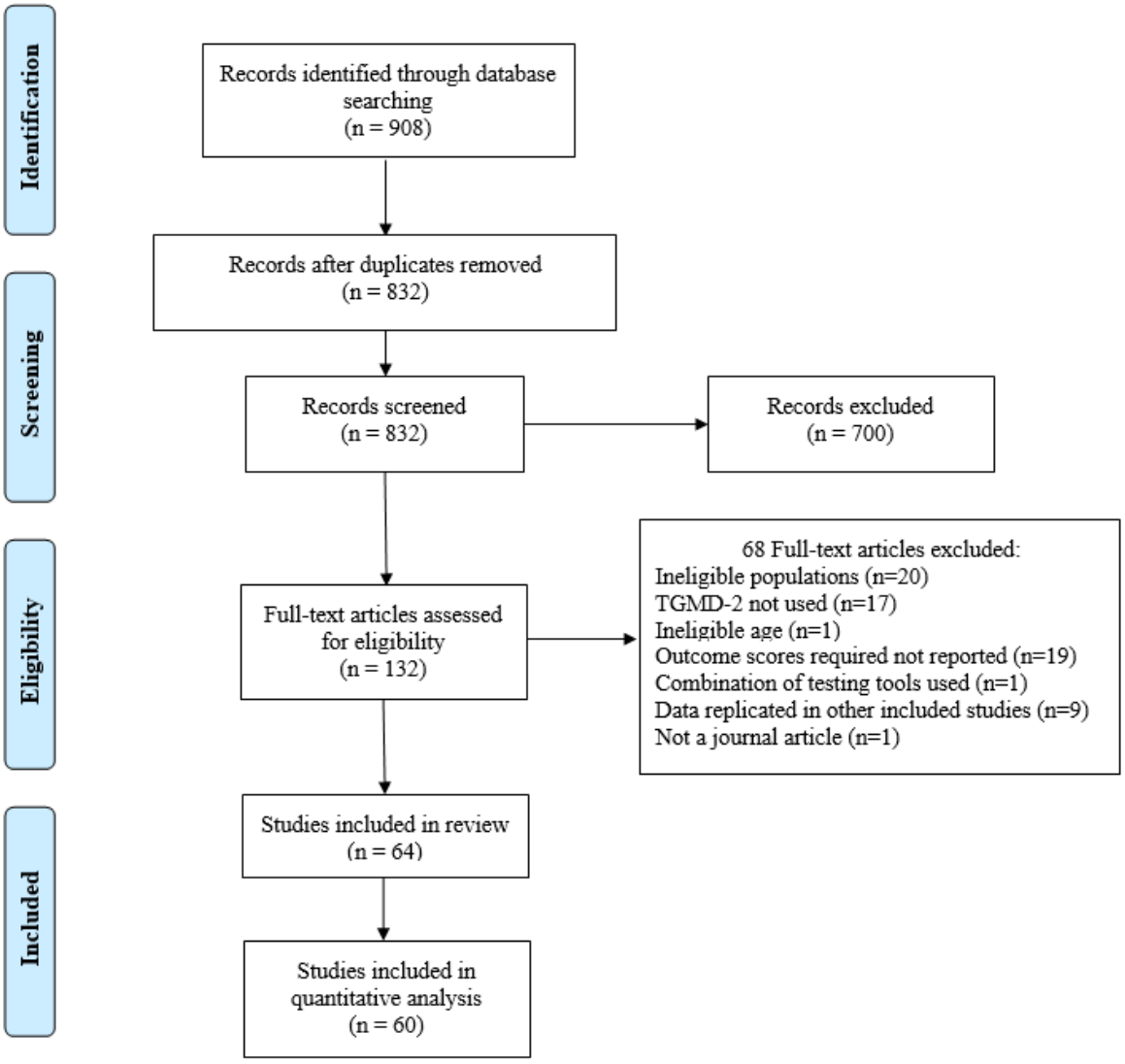


Figure 1. PRISMA flowchart of studies through the review process

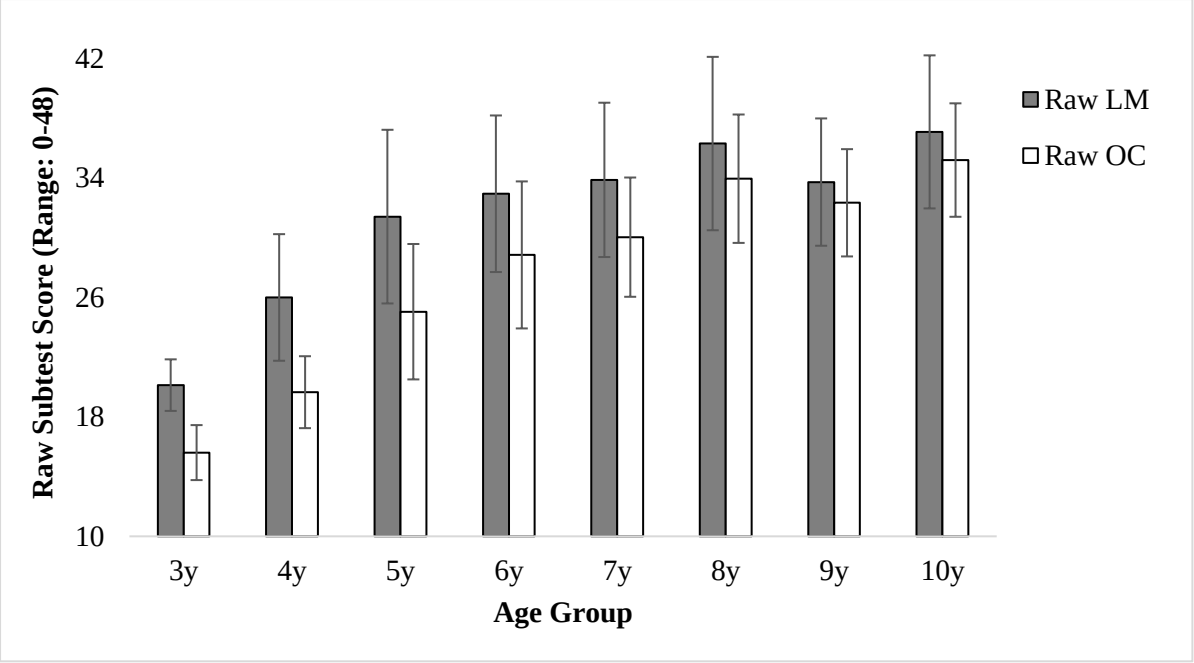
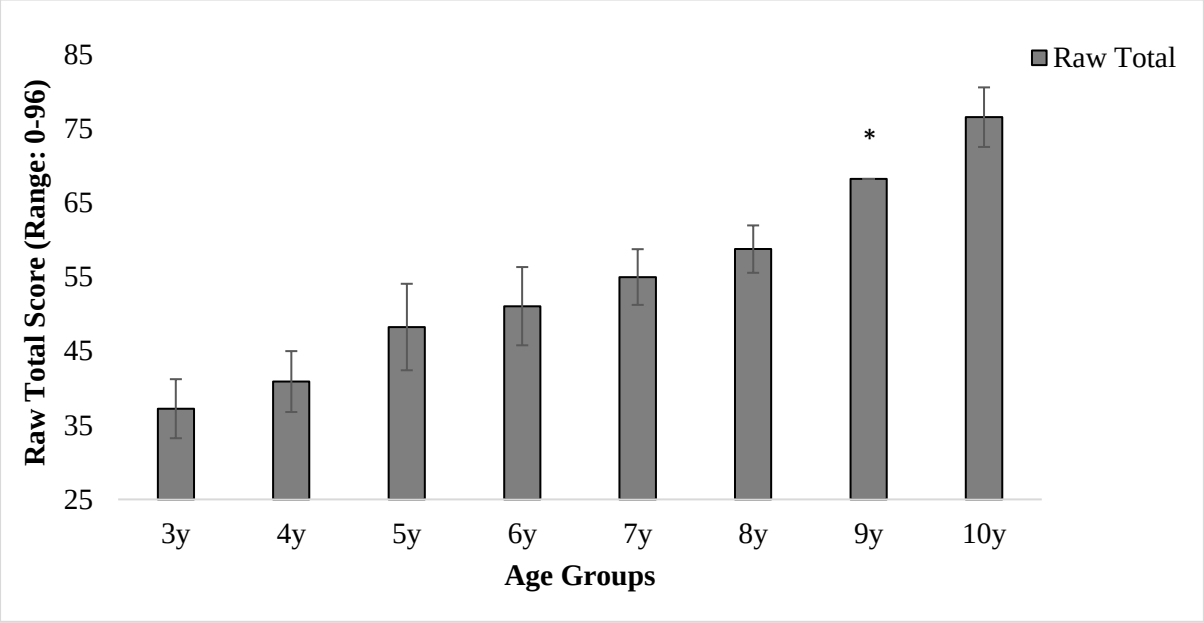
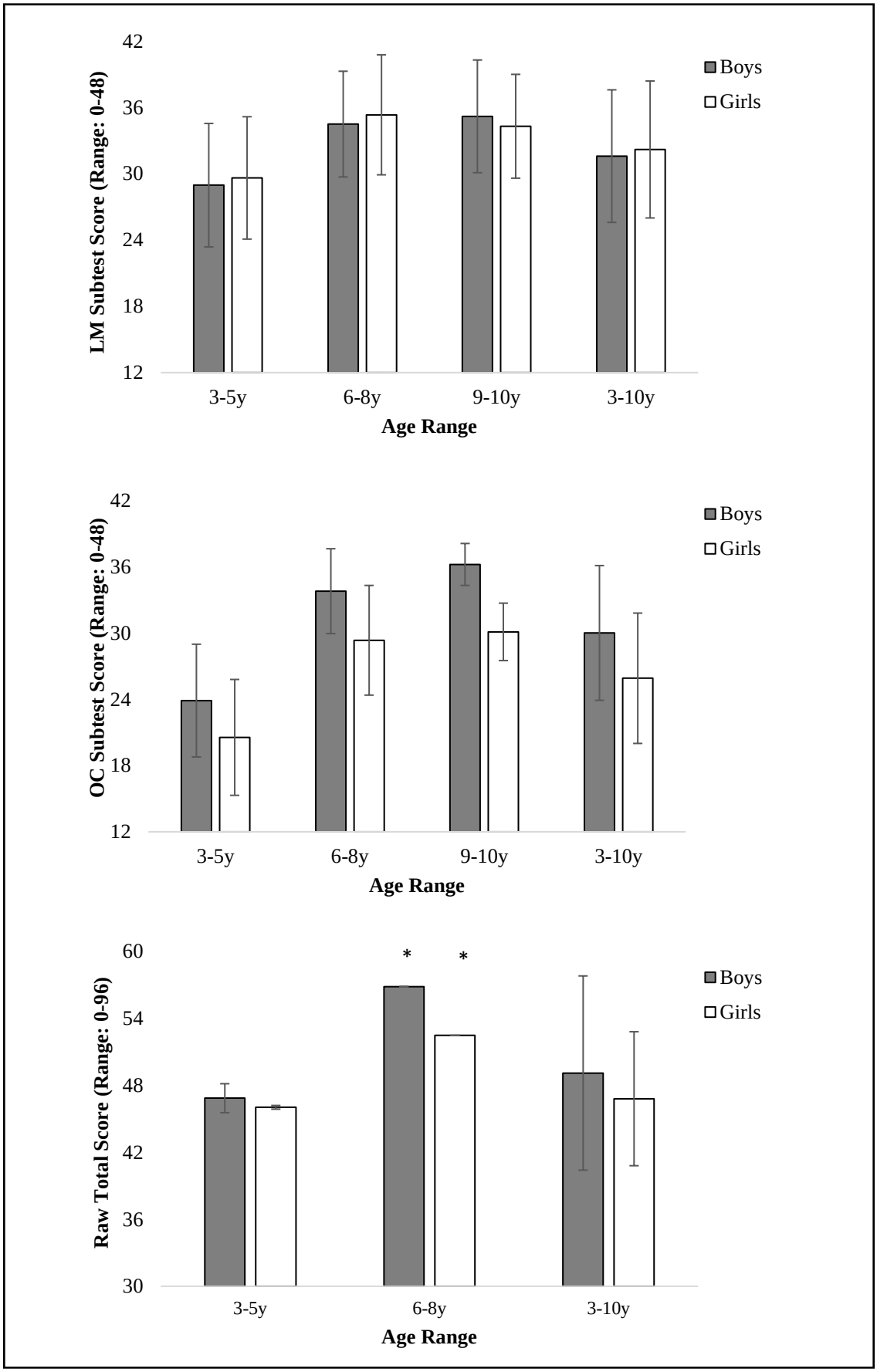


Figure 2. Weighted mean raw subtest scores (± standard deviation) across age groups



* no weighted SD as only one study reported Raw Total Score for 9-10y

Figure 3. Weighted mean raw total FMS score (± standard deviation) across age groups



* no weighted SD as only one study reported Raw Total Score, stratified by sex, for this age range
NOTE: no studies within the 9-10 years age range reported Raw Total Score stratified by sex

Figure 4. Weighted mean raw subtest and total FMS score (± standard deviation) by sex, for each age range

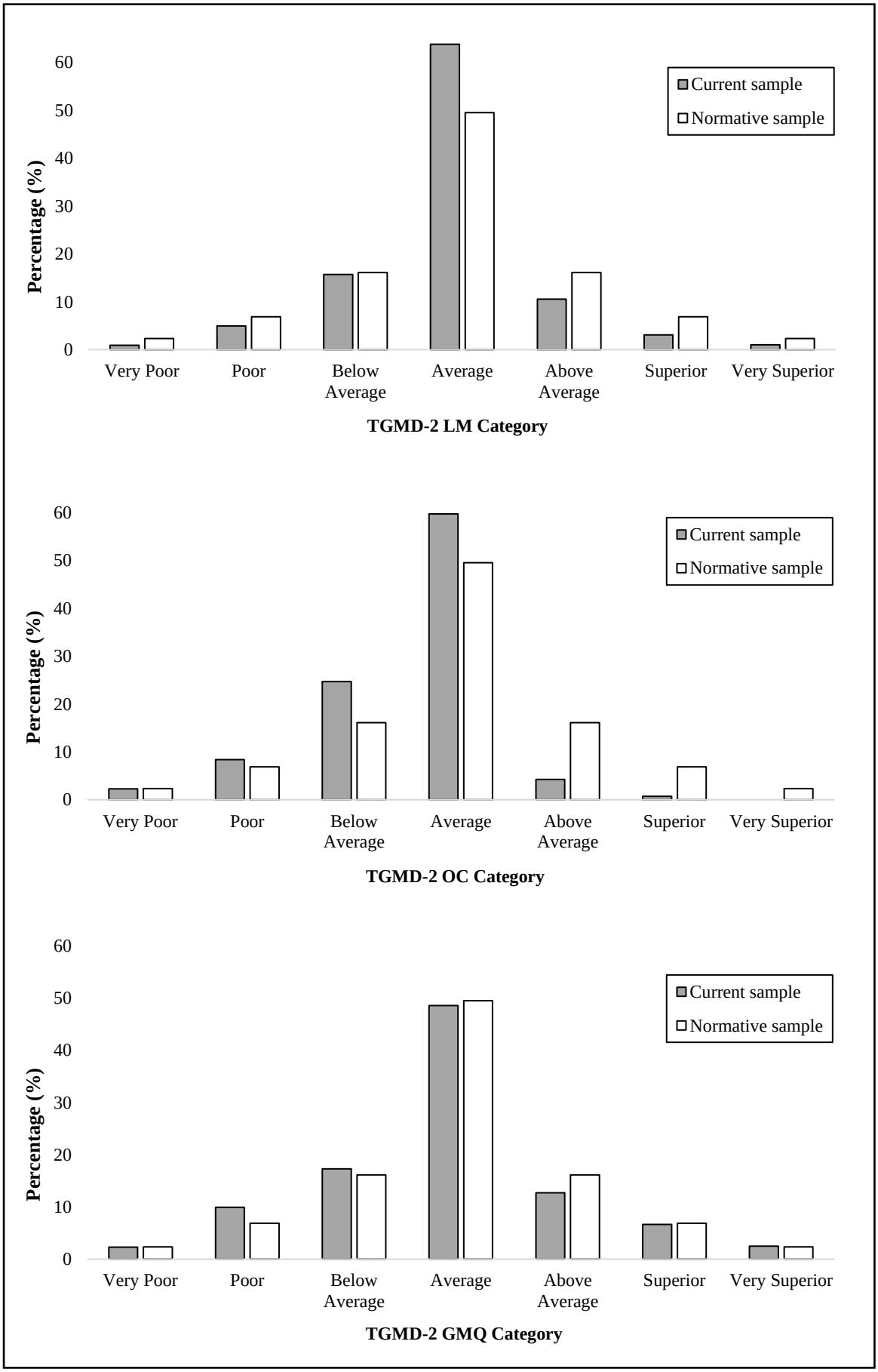


Figure 5. A comparison of the proportion of children classified into each of the TGMD-2 descriptive rating categories with the TGMD-2 US reference sample, for LMSS, OCSS, and GMQ

Table 1. Study characteristics

Authors	Year	Country	Design	Setting	Sample					L/R	No. per group for test	Coders (n)	>85% Reliability		FMS Tested	Scores Reported
					N	Boys	Girls	Age (M: Mean)	Population information				Inter-rater	Intra-rater		
Adamo et al.	2016	Canada	Two-arm cluster RCT	Childcare centers	83 INT: 40 (3-3.9y: 36 4-4.9y: 3) CON: 43 (3-3.9y: 39 4-4.9y: 3)	41 INT: 18 CON: 23	42 INT: 22 CON: 20	3-5 INT: 3.4 ± 0.3 CON: 3.4 ± 0.4	6 licenced childcare centers in Ottawa, Canada (3 interventions, 3 controls)	NR	NR	2	NR	NR	12	SS (LM, OC) GMQ Percentile (LM, OC, GMQ)
Antunes et al.	2016	Portugal	CS	Primary school	158	83	75	6-8	Sub-sample of original study (Healthy Growth of Madeira Study)	NR	1	NR	NR	NR	12	Raw Skill Scores (selected FMS) Subtest Scores (LM, OC)
Aye et al.	2017	Japan	CS	KG	60	34	26	5 M: 5.70 ± 0.31 Boys: 5.66 ± 0.30 Girls: 5.76 ± 0.32	3rd year KG students from a local private KG school in Otawara city, Tochigi Prefecture, Japan	R	3 small groups	NR	NR	NR	12	Raw Skill Scores Raw Subtest Scores (LM, OC) SS (LM, OC) Total SS GMQ Percentile (LM, OC) Distribution across TGMD-2 categories (GMQ)
Aye et al.	2018	Myanmar	CS	KG	472	237	235	5 M: 5.41 ± 0.34 Boys: 5.43 ± 0.35 Girls: 5.39 ± 0.33	2016-2017: 4 schools in urban area (3 public, 1 private in Yangon city area) & 4 public schools in rural area (in Bago Region West)	R	1	3	Yes	NR	12	Raw Skill Scores Raw Subtest Scores (LM, OC) SS (LM, OC) Total SS GMQ Percentile (LM, OC) Distribution across TGMD-2 categories (GMQ)
Bakhtiar	2014	Indonesia	CS	Elementary school	67	28	39	6.08-6.92 M: 6.55 ± 0.25	1st grade (approx. 6-7y) students in	NR	NR	NR	NR	NR	12	Raw Subtest Scores (LM, OC)

								rural and urban area in Pandang, West Sumatera, Indonesia							
Bakhtiari et al.	2011	Iran	QE: Semi-experimental	Elementary school	40 EXP: 20 CON: 20	0	40 EXP: 20 EXP: 20	9 EXP: 8.9 ± 0.49 CON: 8.9 ± 0.48	Third grade girls from elementary school in Ahvaz	NR	NR	NR	NR	NR	12	SS (LM, OC) Percentile (GMQ)
Balaban	2018	Czech Republic	CS	Primary school	201	108	93	8-11 M: 9.22 ± 1.04	3 primary schools in Olomouc, Czech Republic	NR	NR	NR	NR	NR	12	Raw Subtest Scores (LM, OC) Raw Total FMS GMQ Distribution across TGMD-2 categories (GMQ)
Bardid et al.	2016	Belgium	CS	51 child settings including sports clubs, local councils, schools & day-care centres	1614 3y: 234 4y: 374 5y: 330 6y: 323 7y: 210 8y: 143	841 3y: 121 4y: 215 5y: 181 6y: 159 7y: 103 8y: 62	773 3y: 131 4y: 159 5y: 149 6y: 164 7y: 107 8y: 81	3-8	51 settings (sports clubs, local councils, schools, day care centres) from all 5 Flemish provinces & Brussels Capital Region	L	NR	NR	NR	NR	12	Raw Skill Scores Raw Subtest Scores (LM, OC) SS (LM, OC) GMQ Distribution across TGMD-2 categories (LM, OC, GMQ)
Barnett et al.	2015	Australia	CS	3 primary schools	102	57	45	4-8 M: 6.3 ± 0.92	First 3 year levels of 3 primary schools	L	NR	2	Yes	NR	6 OC	Raw Subtest Score (OC)
Barnett et al.	2013	Australia	CS	Preschools/ childcare centres within 2 local government areas	76	34	42	3-6 M: 4.1 ± 0.68	Preschools/ childcare centres within 2 local government areas	L	NR	4	Yes	NR	12	Raw Subtest Scores (LM, OC)
Cenizo Benjumea et al.	2017	Seville, Spain	QE	Primary school	982 Grade 1: 505 Grade 2: 477 EXP 1 (6-7y): 73 EXP 1 (8-9y): 82 EXP 2	EXP 1 (6-7y): 40 EXP 1 (8-9y): 38 EXP 2 (6-7y): 81 EXP 2 (8-9y): 61 EXP 3	EXP 1 (6-7y): 33 EXP 1 (8-9y): 44 EXP 2 (6-7y): 87 EXP 2 (8-9y): 55 EXP 3	6-9	8 primary schools in Seville	NR	NR	NR	NR	NR	12	Raw Subtest Scores (LM, OC)

					(6-7y): 168 EXP 2 (8-9y): 116 EXP 3 (6-7y): 200 EXP 3 (8-9y): 181 CON (6-7y): 72 CON (8-9y): 114	(6-7y): 99 EXP 3 (8-9y): 87 CON (6-7y): 38 CON (8-9y): 57	(6-7y): 101 EXP 3 (8-9y): 94 CON (6-7y): 34 CON (8-9y): 57								
Bolger et al.	2018	Ireland	CS	Primary school	203 SI: 102 4th Class: 101	1108 SI: 52 4th Class: 58	93 SI: 50 4th Class: 43	6 & 10 SI: 6.0 ± 0.4 Boys SI: 5.9 ± 0.9 Girls SI: 6.0 ± 0.4 4th Class: 9.9 ± 0.4 Boys 4th Class: 10.0 ± 0.4 Girls 4th Class: 9.8 ± 0.4	3 primary schools (1 rural mixed and 2 urban single sex: 1 boys and 1 girls, from a region in southern Ireland)	R	Groups of 5-8 (stations)	2	Yes	Yes	12	Raw Subtest Scores (LM, OC) GMQ Mastery Levels
Brian et al.	2017	US	QE	Early childhood centre at a large Midwestern University in the US	57 EXP: 26 CON: 31	30 EXP: 14 CON: 17	27 EXP: 12 CON: 14	3-6 M: 4.39	Early childhood centre at a large Midwestern University in the US	NR	NR	3	Yes	NR	6 OC	Raw Subtest Score (OC) SS (OC) Percentile (OC)
Butterfield et al.*	2012	US	CS	Rural primary school	186 6y: 17 7y: 21 8y: 13 9y: 17 10y: 25 11y: 28 12y: 17 13y: 21	105 6y: 7 7y: 9 8y: 8 9y: 9 10y: 14 11y: 17 12y: 10 13y: 16	81 6y: 10 7y: 12 8y: 5 9y: 8 10y: 11 11y: 11 12y: 7 13y: 5	5-14 M: 9.6 ± 2.5 Boys: 10.0 ± 2.4 Girls: 9.1 ± 2.5	Grades K-8	NR	NR	2	Yes	NR	4 OC (catch, throw, kick, strike)	Mastery Levels
Cano-Cappellacci et al.	2015	Chile	CS: validation & reliability study	Primary school in Santiago, Chile	92	56	36	5-10 M: 7.5 ± 1.6	Primary school in Santiago, Chile	R	3	2	Yes	Yes	12	Raw Subtest Scores (LM, OC)

Capio et al.*	2013	China	QE	Primary school	216 Error-strewn (ES): 117 Error-reduced (ER): 99	109 ER: 50 ES: 59	107 ER: 49 ES: 58	8-12 M: 9.16 ± 0.96	2 training programs assigned: Error-reduced (ER) Error-Strewn (ES)	L	NR	4	Yes	NR	1 (throw)	Raw Skill Score
Cepicka	2010	Czech Republic	CS	Urban elementary schools	315	152	163	approx. 6-7 Boys: 7.1 ± 0.3 Girls: 7.0 ± 0.3	Grade 1	NR	NR	NR	NR	NR	12	Raw Subtest Scores (LM, OC) Percentile (LM, OC)
Chan et al.*	2018	Hong Kong, China	CS	6 primary schools in Hong Kong	568 Grade 1-3: 278 Grade 4-6: 290	229 Grade 1-3: 114 Grade 4-6: 115	339 Grade 1-3: 164 Grade 4-6: 175	6-12 M: 9.3 ± 1.7 Grade 1-3: 6-9 Grade 4-6: 9-12	6 primary schools in Hong Kong, Year 1 to 6	L	Groups of 3-4 (stations)	8	Yes	NR	12	Raw Subtest Scores (LM, OC)
Chow & Chan	2011	China	CS	Preschool	239	121	118	3-6 M: 3.6 ± 0.2	Children from KG Year 1 - KG Year 3, attending 4 preschools in Hong Kong	R	NR	1	NR	NR	12	Raw Subtest Scores (LM, OC) Raw Total FMS Percentile (LM, OC)
Clark et al.	2018	United Kingdom	CS	Primary school	58	29	29	8-10 M: 9.5 ± 0.6	Primary school in Santiago, Chile	NR	NR	2	Yes	NR	12	Percentile (LM, OC)
Cliff et al.	2009	Australia	CS	Preschool	46	25	21	3-5 M: 4.3 ± 0.7	11 preschools within the city of Greater Wollongong, New South Wales	R	1	1	NR	NR	12	Raw Subtest Scores (LM, OC) SS (LM, OC) GMQ
Crane et al.	2017	Canada	Longitudinal	8 elementary schools in one school district in British Columbia, Canada	250	124	126	KG (approx. 5-6): M: 5.8 ± 0.3 Grade 2 (approx. 7-8): M: 7.7 ± 0.4	Children attending 8 elementary schools in one school district in British Columbia, Canada were assessed at KG and again in Grade 2 for FMS	R	Groups of 3-5 (stations)	1	NR	NR	12	Raw Skill Scores Raw Subtest Scores (LM, OC)
da Silva et al.	2017	Brazil	CS	Municipal school in Campina Grande do	72	33	39	3.17-3.50	Municipal school in Campina Grande do Sul, Paraná, Brazil	R	1	2	NR	NR	12	Percentile (LM, OC, GMQ)

			Sul, Paraná, Brazil												
de Meester et al.*	2016	US	CS	64 children attending urban school district in Ohio 196 children attending rural school in Texas 101 children attending a before and after school program in Michigan	361	180	181	6.92-11.83 M: 9.5 ± 1.24	64 children attending urban school district in Ohio 196 children attending rural school in Texas 101 children attending a before and after school program in Michigan	NR	1	NR	NR	NR	12	Percentile (GMQ)
dos Santos et al.	2016	Portugal	CS		Portugal: 853 4y: 95 5y: 107 6y: 113 7y: 103 8y: 102 9y: 104 10y: 167	426	427	4-10	4-10 year olds; 3 studies included: Wong (2002) Ulrich (2000) Afonso (2009)	NR	NR	NR	NR	NR	1 (kick)	Mastery Levels
Du Plessis et al.	2015	South Africa	CS; Randomised longitudinal: Baseline	Primary school	806	413	393	6.84 ± 0.39 (approx. 6-7)	Baseline data of NW-CHILD longitudinal study (Grade 1: 20 schools from 4 districts)	NR	NR	NR	NR	NR	6 OC	Raw Skill Scores
Field & Temple	2017	Canada	CS	8 public elementary schools in British Columbia, Canada	400	195	205	9.5 (approx. 9-10)	Grade 4 (approx. 9-10)	R	approx. 7 (stations)	1	NR	NR	12	Raw Subtest Scores (LM, OC)
Freitas et al.	2015	Portugal	CS	Primary school	429	213 7y: 48 8y: 51	216 7y: 45 8y: 41	7-10 Boys 7y: 7.5 ± 0.3 Girls 7y: 7.5 ± 0.3 Boys 8y: 8.5 ± 0.3	40 schools randomly selected from the 11	NR	NR	NR	NR	NR	12	Raw Skill Scores Raw Subtest Scores

					9y: 45 10y: 69	9y: 52 10y: 78	Girls 8y: 8.5 ± 0.3 Boys 9y: 9.5 ± 0.3 Girls 9y: 9.4 ± 0.3 Boys 10y: 10.6 ± 0.3 Girls 10y: 11.0 ± 1.4	districts of Madeira & Porto Santo						(LM, OC)
Grant-Beuttler et al.	2017	US	CS	Flyers posted at local school districts, at professional meetings and given to friends of participants, between 4-9y	54 4y: 9 5y: 9 6y: 9 7y: 9 8y: 9 9y: 9	27 4y: 4 5y: 5 6y: 4 7y: 5 8y: 5 9y: 4	27 4y: 5 5y: 4 6y: 5 7y: 4 8y: 4 9y: 5	4-10 4y: 4.5 ± 0.4 5y: 5.7 ± 0.2 6y: 6.4 ± 0.2 7y: 7.5 ± 0.2 8y: 8.2 ± 0.2 9y: 9.7 ± 0.3	Flyers posted at local school districts, at professional meetings and given to friends of participants, between 4-9y	R	1	2	NR	NR	1	SS (LM, OC) GMQ
Hall et al.	2018	Britain	CS	State funded childcare provisions within the Coventry and Warwickshire area (schools & preschools)	166	91	75	3-5 M: 4.28 ± 0.74	State funded childcare provisions within the Coventry & Warwickshire area (schools & preschools)	R	NR	2	Yes	Yes	12	Raw Subtest Scores (LM, OC) Raw Total FMS
Hardy et al.	2010	Sydney, Australia	CS	Preschool	330	171	159	4.0-4.9	Preschools in Sydney, Australia	L	1	NR	Yes	NR	8 (4 LM: run, gallop, hop, jump; OC: strike, catch, kick, throw)	Raw Skill Scores Raw Subtest Scores (LM, OC: each included 4 of 6 skills) Raw Total FMS (8 skills) Mastery Levels
Henrique et al.	2016	Brazil	Longitudinal	Preschool	248 Test Sample: 206 Dropout Sample: 42	201 Test Sample: 115 Dropout Sample: 86	135 Test Sample: 91 Dropout Sample: 44	3-5 Test Sample: 4.83 ± 0.78 Boys: 4.78 ± 0.85 Girls: 4.88 ± 0.67 Dropout Sample: 4.69 ± 0.83	Recruited from the Observational Longitudinal Study on Health and Welfare of Preschool Children - 28 schools in 6	NR	NR	2	Yes	Yes	12	SS (LM, OC)

							Boys: 4.78 ± 0.92 Girls: 4.60 ± 0.74	political administrative regions of north-eastern Brazil							
Invernissi et al.	2019	Italy	CS	Primary school	121 INT: 62 CON: 59	57 INT: 33 CON: 24	64 INT: 29 CON: 35	M: 10.5 ± 0.5 (approx. 10-11)	Fifth grade students attending 3 primary/ elementary schools in Milan	NR	NR	NR	NR	NR	12	Raw Subtest Scores (LM, OC) Raw Total FMS
Johnstone et al.	2017	Scotland	QE: Pragmatic evaluation	Primary school	123 INT: 102 CON: 21	90 INT: 82 CON: 8	106 INT: 90 CON: 16	M: 7.0 ± 1.0 (approx. 4-9)	7 primary schools involving classes from grades 1-5 (INT), grades 2-4 (CON)	NR	NR	NR	NR	NR	12	SS (LM, OC) GMQ Percentile (LM, OC, GMQ)
Khodaverdi et al.	2016	Iran	CS	Public primary schools	352	0	352	8-9 M: 8.78 ± 0.32	Public primary schools located in the urban southwestern part of Tehran Province (3rd Grade)	R	NR	2	Yes	NR	12	Raw Subtest Scores (LM, OC) GMQ
Kim et al.	2014	South Korea	Validity & Reliability	Southern region of Seoul, South Korea (3 of the 25 boroughs of Seoul)	139			3-10 M: 6.8 ± 1.9	Southern region of Seoul, South Korea (3 of the 25 boroughs of Seoul)	R	NR	3	Yes	NR	12	Raw Skill Scores Raw Subtest Scores (LM, OC)
Kit et al.	2017	US	CS	CDC/ NHANES National Youth Fitness Survey	339 3y: 107 4y: 113 5y: 119	171	168	3-5	The NHANES National Youth Fitness Survey (NNYFS) was conducted in 2012 by the Division of Health and Nutrition Examination Surveys of NCHS (3-5 year old data included)	NR	NR	NR	NR	NR	12	Raw Subtest Scores (LM, OC) SS (LM, OC) Distribution across TGMD-2 categories (LM, OC)

Korbecki et al.	2017	Poland	CS	Elementary school	98 6y: 64 7y: 34	55: 6y: 35 7y: 20	43 6y: 29 7y: 14	6-7	Grade 1 of elementary school in Krosno	L	NR	3	NR	NR	12	Raw Skill Scores Raw Subtest Scores (LM, OC)
Kordi et al.	2012	Iran	QE	Nursery school	147	75	72	4-6 M: 4.95 ± 0.83	5 nursery schools in 5 cities in Iran	NR	NR	NR	NR	NR	12	Raw Subtest Scores (LM, OC) SS (LM, OC, Total) GMQ Distribution across TGMD-2 categories (GMQ) Age Equivalent (LM, OC): Proportion at each band
LeGear et al.	2012	Canada	CS	KG	260	135	125	5.75 (approx. 5-6)	KG children from 8 schools in one school district in British Columbia, Canada	R	Groups of 3-5 (stations)	2	Yes	NR	12	Raw Subtest Scores (LM, OC) Raw Total FMS
Lin & Yang	2015	Taiwan	CS	Elementary school	485 8-9y: 196 6-7y: 92 7-8y: 197	244	241	6-9 M: 7.67	From Chiayi City & Chiayi County	R	NR	4	Yes	NR	12	Raw Skill Scores Raw Subtest Scores (LM, OC) Raw Total FMS
Liong et al.	2015	Australia	CS	Primary school	136	70	66	5-8 M: 6.5 ± 1.1	2 elementary schools	NR	2-3	2	Yes	NR	12	Raw Subtest Scores (LM, OC) Raw Total FMS
Logan et al.	2011	US	CS	Preschool	32	15	17	3-6 M: 4.2 ± 0.9	From a public childcare centre in the southeast region of the US	R	NR	1	Yes	NR	12	Percentile (LM, OC, GMQ)
Logan et al.	2014	US	CS	Elementary school	65 KG: 20 Grade 1: 22 Grade 2: 23	32 KG: 10 Grade 1: 13 Grade 2: 9	33 KG: 10 Grade 1: 9 Grade 2: 14	M: 6.7 KG: 5.7 ± 0.38 Grade 1: 6.7 ± 0.34 Grade 2: 7.8 ± 0.46	KG to 2nd grade children attending a public elementary school in the southeast region of the US	R	3-5	2	Yes	Yes	12	SS (LM, OC) GMQ Percentile (GMQ)
Miklánková	2018	Czech Republic	CS	Preschool	62	25	37	M: 5.8 ± 0.38	Preschools in Czech Republic	NR	NR	NR	NR	NR	12	GMQ

Miller et al.*	2015	Australia	Cluster RCT	Primary school	168 INT: 97 CON: 71	72 INT: 38 CON: 34	96 INT: 59 CON: 37	10-12 INT: 11.12 ± 1.28 CON: 11.20 ± 0.61	Year 6 students from 7 primary schools	R	NR	1	Yes	Yes	3 OC (throw, catch, kick)	Raw Skill Score
Mukherjee et al.	2017	Singapore	CS	Primary school	244 Primary 1 (P1): 120 Primary 3 (P3): 124	132 P1: 60 P3: 72	112 P1: 60 P3: 52	6-9 P1: 6-7.5 P2: 8-9	4 government-aided primary schools	R	NR	NR	Yes	Yes	12	Raw Subtest Scores (LM, OC) Raw Total FMS SS (LM, OC) GMQ Percentile (LM, OC, GMQ) Distribution across TGMD-2 categories (GMQ) Age Equivalent (LM, OC) Mastery Levels
Palmer & Brian	2016	US	CS: Comparison of novice & expert coders	Preschool centre in southern United States	43	25	18	4-5 M: 4.88 ± 0.28	Preschool centre in southern United States	R	NR	3	Yes	NR	12	Raw Skill Scores Raw Subtest Scores (LM, OC)
Pang & Fong	2009	China	CS	Primary school	167	91	76	6-9 M: 7.6 ± 0.9	6 primary schools in Hong Kong	R	NR	1	Yes	Yes	12	Raw Subtest Scores (LM, OC) SS (LM, OC, Total) GMQ Percentile (LM, OC, GMQ) Distribution across TGMD-2 categories (LM, OC, GMQ) Age Equivalent (LM, OC)
Pienaar et al.	2015	South Africa	CS: Follow-up 1 of longitudinal study	Primary school	826	433	393	9-10 M: 9.9 ± 0.63	First follow-up group of the NW-CHILD study: From 4 of 8 educational districts in the North West	NR	NR	2	Yes	NR	6 OC	Raw Skill Scores SS (OC) Percentile (OC) Distribution across TGMD-2 categories (OC)

								province of South Africa, representing 5 school quintiles; Grade 3 & 4 children							Age Equivalent (OC)
Rechtik	2018	Czech Republic	CS	Preschool	232	102	130	5.9 ± 1.63	KGs & nursery schools	NR	NR	NR	NR	NR	12	Raw Subtest Scores (LM, OC) GMQ Distribution across TGMD-2 categories (GMQ)
Robinson et al.	2012	US	CS	Preschool	34	12	22	3-5 M: 4.75 ± 0.53 Boys: 4.77 ± 0.66 Girls: 4.74 ± 0.46	Preschool children from a subsidized early childcare center located in a rural, southeastern US town	R	NR	1	Yes	NR	12	Raw Subtest Scores (LM, OC)
Robinson et al.	2012	US	CS	Preschool	14	8	6	3-5 M: 4.61 ± 0.46	Children from a university-based early learning center in the southeast region of the US	R	NR	1	Yes	NR	12	Percentile (LM, OC, GMQ)
Rudd et al.*	2016	Australia	CS	Primary school	158	86 6-8y: 24 8-10y: 31 10-12y: 31	72 6-8y: 21 8-10y: 26 10-12y: 25	6-12 M: 9.5 ± 2.2	Australian children	R	4 (stations)	2	Yes	NR	12	Raw Subtest Scores (LM, OC)
Rudd et al.	2017	Australia	QE	Primary school	333 INT: 135 CON: 198	171 INT: 69 CON: 102	162 INT: 66 CON: 96	6-10 M: 8.1 ± 1.1	Grade 1-4 children from 3 primary schools	NR	5 (stations)	2	Yes	NR	12	Raw Subtest Scores (LM, OC)
Slykerman et al.	2016	Australia	CS	Primary school	109	59	50	5-8 M: 6.5 ± 1.0	2 primary schools in Victoria	NR	NR	NR	Yes	NR	12	Raw Subtest Scores (LM, OC)
Spessato et al.	2013	Brazil	CS	Public schools	178	82	96	4-7 M: 5.36 ± 1.0	8 Public schools in Rio Grande do Sul	R	1	3	NR	NR	12	Raw Total FMS Distribution across TGMD-2 categories (GMQ)
Spessato et al.	2013	Brazil	CS	Public schools & day-care centres	1248 3-4y: 212 5-6y: 348	641 3-4y: 109 5-6y: 175	607 3-4y: 103 5-6y: 173	3-10 3-4y: 4.0 ± 0.5 5-6y: 6.1 ± 0.6	50 public schools & day-care centres in a large,	R	NR	2	Yes	NR	12	Age Equivalent (LM, OC)

				7-8y: 326 9-10y: 362	7-8y: 177 9-10y: 180	7-8y: 149 9-10y: 182	7-8y: 8.0 ± 0.6 9-10y: 9.8 ± 0.5	metropolitan city, South Brazil						
Tomaz et al.	2019	South Africa	CS	Preschool	259 Urban High Income (UH): 46 Urban Low Income (UL): 91 Rural Low Income (RL): 122	130	129	3-6 UH: 5.2 ± 0.7 UL: 5.4 ± 0.7 RL: 5.0 ± 0.6	UH setting (Cape Town), UL setting (Cape Town), and RL setting (Bushbuckridge) in Mpumalanga Province in Northern South Africa	R	4-7	2	Yes	NR	12	Distribution across TGMD-2 categories (GMQ)
Valentini	2016	Brazil	CS: validation & reliability study	Primary school	2674 3y: 94 4y: 123 5y: 220 6y: 359 7y: 412 8y: 577 9y: 537 10y: 352	1352 3y: 52 4y: 61 5y: 108 6y: 173 7y: 222 8y: 285 9y: 266 10y: 185	1322 3y: 42 4y: 62 5y: 112 6y: 186 7y: 190 8y: 292 9y: 271 10y: 167	3-10 M: 7.56 ± 1.91	Schools from 15 cities from 10 states (2 states from each region) in Brazil	R	1	3	Yes	Yes	12	Raw Skill Scores Raw Subtest Scores (LM, OC)
Wong & Cheung	2006	China	CS	KGs & 2005 YMCA of Hong Kong Summer Camp	1228 3y: 115 4y: 245 5y: 270 6y: 167 7y: 127 8y: 89 9y: 108 10y: 107	675 3y: 50 4y: 134 5y: 152 6y: 88 7y: 58 8y: 51 9y: 68 10y: 74	553 3y: 65 4y: 111 5y: 118 6y: 79 7y: 69 8y: 38 9y: 40 10y: 33	3-10 M: 6.45 ± 2.1	4 KGs & 2005 YMCA of Hong Kong Summer Camp	R	NR	1	Yes	NR	12	Raw Subtest Scores (LM, OC) Mastery Levels
Wong & Cheung	2010	China	CS	KGs and YMCA of Hong Kong Summer Camp	614	325	289	3-10 M: 6.49 ± 2.10	Hong Kong Chinese children from 4 KGs & YMCA of Hong Kong Summer Camp	L & R	5-10 (Stations)	4	Yes	NR	12	Raw Skill Scores
Yang et al.	2015	Taiwan	CS	Preschool	1029 3-4y: 104 4-5y: 331 5-6y: 357 6-7y: 237	516 3-4y: 62 4-5y: 169 5-6y: 169 6-7y: 116	513 3-4y: 42 4-5y: 162 5-6y: 188 6-7y: 121	3-7 M: 5.1 ± 0.83	12 preschools in one of the 4 regions of Taiwan	R	1	4	Yes	NR	12	Raw Skill Scores Raw Subtest Scores (LM, OC) Raw Total FMS

Zuvela et al.	2011	Croatia	Construction & validation of new FMS tool	Elementary school	95	48	47	8 M: 8.1 ± 0.3	Randomly selected from 300 children from 3 schools	NR	NR	NR	NR	NR	12	Raw Total FMS

FMS: Fundamental Movement Skills

RCT: Randomised control trial; CS: Cross-sectional; QE: Quasi-experimental

INT: Intervention group; CON: Control group; EXP: Experimental group; SI: Senior Infants

L: Live, R: Retrospective; NR: Not reported

LM: Locomotor; OC: Object control; SS: Standard Score; GMQ: Gross Motor Quotient

KG: Kindergarten

M: Mean; y: years

Bel: Belgium; US: United States

CDC: Centers for Disease Control and Prevention; NHANES: National Health and Nutrition Examination Survey; NCHS: National Center for Health Statistics

Max.: Maximum

*denotes studies that include children between the ages of 3-10 and older. Only data relating to children between 3-10 years are included in the analyses

Table 2. Summary of the results of studies that reported raw subtest and total scores based on the TGMD-2

Author	Age	n	Group	Raw		
				LM	OC	Total
Antunes et al.	6 (6.72 ± 0.2)	27	Boys	32.0 (5.8)	30.7 (5.2)	
	6 (6.64 ± 0.2)	23	Girls	30.8 (7.2)		
	7 (7.58 ± 0.2)	28	Girls	35.7 (3.7)		
	7 (7.62 ± 0.2)	29	Boys	35.4 (5.1)	32.8 (5.7)	
	8 (8.59 ± 0.3)	27	Boys	37.6 (4.1)	35.9 (3.9)	
	8 (8.68 ± 0.3)	24	Girls	37.7 (4.1)		
Aye et al.	5 (M: 5.43 ± 0.35)	237	Boys	38.8 (7.66)	31.8 (7.53)	
	5 (M: 5.39 ± 0.33)	235	Girls	38.6 (7.07)	27.8 (7.30)	
	5 (M: 5.41 ± 0.34)	472		38.7 (7.36)	29.8 (7.67)	
Aye et al.	5 (M: 5.70 ± 0.31)	60		38.5 (5.71)	36.4 (6.57)	
	5 (M: 5.66 ± 0.30)	34	Boys	36.6 (6.40)	37.8 (6.24)	
	5 (M: 5.76 ± 0.32)	26	Girls	41.0 (3.36)	34.5 (6.62)	
Bakhtiar	6.08-6.92	28	Boys	39.21 (5.28)	37.57 (7.48)	
	6.08-6.92	39	Girls	35.92 (8.17)	35.59 (6.29)	
Balaban	8-11.99	108	Boys	46.29 (3.19)	42.64 (5.38)	89.06 (6.90)
	8-11.99	93	Girls	46.68 (1.69)	39.58 (5.38)	86.09 (6.47)
	8-11.99 (M: 9.22 ± 1.04)	201		46.47 (2.90)	41.22 (5.47)	87.68 (6.85)
Bardid et al.	3	113	Girls	20.4 (8.0)	14.1 (5.3)	
	3	121	Boys	19.7 (7.7)	17.5 (6.3)	
	3	234		20.0 (7.8)	15.9 (6.0)	
	4	159	Girls	29.7 (6.9)	18.1 (5.3)	
	4	215	Boys	28.0 (8.1)	22.3 (6.0)	
	4	374		28.7 (7.6)	20.5 (6.1)	
	5	149	Girls	34.4 (6.0)	23.3 (5.6)	
	5	181	Boys	33.6 (6.3)	27.4 (6.4)	
	5	330		34.0 (6.2)	25.6 (6.4)	
	6	164	Girls	37.1 (5.6)	26.5 (5.8)	
	6	159	Boys	36.5 (5.6)	33.1 (6.4)	
	6	323		36.8 (5.6)	29.8 (7.0)	
	7	107	Girls	38.5 (4.9)	29.7 (6.1)	
	7	103	Boys	38.1 (4.8)	36.4 (5.6)	
	7	210		38.3 (4.9)	33.0 (6.7)	
	8	81	Girls	38.4 (4.2)	32.4 (5.2)	
	8	62	Boys	39.6 (5.3)	38.1 (4.6)	
	8	143		38.9 (4.7)	34.9 (5.7)	
Barnett et al.	4-8 (M: 6.3 ± 0.92)	102			31.4 (7.5)	
	4-8	57	Boys		33.8 (7.0)	
	4-8	45	Girls		28.4 (6.9)	
Barnett et al.	3-6 (M:4.1 ± 0.68)	76		29.51 (7.65)	26.03 (8.38)	
Cenizo Benjumea et al.	6-7	40	EXP 1: Boys	39.84 (5.46)	38.8 (6.88)	
	8-9	38	EXP 1: Boys	41.82 (5.62)	42.48 (5.40)	
	6-7	33	EXP 1: Girls	40.48 (5.61)	34.55 (7.67)	
	8-9	44	EXP 1: Girls	42.18 (4.43)	40.18 (5.32)	
	6-7	81	EXP 2: Boys	35.11 (5.51)	34.41 (6.07)	
	8-9	61	EXP 2: Boys	40.75 (5.20)	39.83 (5.83)	
	6-7	87	EXP 2: Girls	35.51 (4.59)	32.14 (5.85)	
	8-9	55	EXP 2: Girls	40.41 (5.39)	36.97 (7.09)	
	6-7	99	EXP 3: Boys	34.90 (4.33)	37.1 (4.53)	
	8-9	87	EXP 3: Boys	37.79 (5.24)	36.61 (6.57)	
	6-7	101	EXP 3: Girls	32.42 (6.31)	32.97 (5.48)	
	8-9	94	EXP 3: Girls	37.59 (5.11)	35.36 (5.72)	
	6-7	38	CON: Boys	34.82 (8.28)	31.74 (8.19)	
	8-9	57	CON: Boys	41.74 (6.28)	40.65 (7.76)	
	6-7	34	CON: Girls	36.26 (7.96)	29.44 (9.37)	
	8-9	57	CON: Girls	40.79 (7.28)	36.11 (7.93)	
Bolger et al.	6 (M: 5.9 ± 0.9)	52	Boys	37.6 (4.2)	32.0 (4.9)	
	6 (M: 6.0 ± 0.4)	50	Girls	40.3 (3.8)	26.0 (4.8)	
	10 (M: 10.0 ± 0.4)	58	Boys	41.2 (3.5)	40.3 (3.5)	
	10 (M: 9.8 ± 0.4)	43	Girls	41.9 (4.0)	37.4 (4.3)	
Brian et al.	3-6 (M: 4.39)	26	EXP		16 (1.1)	
	3-6 (M: 4.39)	31	CON		18 (1.4)	
Cepicka	7.0 ± 0.3	163	Girls	37.18 (4.82)	27.29 (5.86)	

	7.1 ± 0.3	152	Boys	33.19 (5.26)	32.81 (5.39)	
Chow & Chan	3-3.9	53		22.34 (7.6)	18.83 (6.51)	41.17 (11.73)
	4-4.9	68		25.65 (6.63)	22.38 (5.95)	48.03 (10.53)
	5-5.9	80		34.03 (6.75)	28.86 (8.6)	62.89 (13.56)
	6	38		33.61 (6.17)	28.79 (7.56)	62.39 (10.89)
Cano-Cappellacci et al.	5	16				57.8 (10.1)
	6	15				65.2 (7.7)
	7	13				64.6 (8.2)
	8	17				68.9 (8.8)
	9	23				68.2 (5.9)
	10	8				65.5 (6.4)
	5-10	36	Girls			61.2 (9.1)
	5-10	56	Boys			68.2 (7.1)
	5-10 (7.5 ± 1.6)	92		34.7 (4.7)	33.1 (4.2)	65.5 (8.6)
Chan et al.	6-9	114	Grade 1-3: Boys	35.8 (6.4)	35.8 (6.8)	
	6-9	164	Grade 1-3: Girls	38.6 (5.4)	33.5 (7.5)	
	10-12	115	Grade 4-6: Boys	39.9 (5.6)	42.6 (4.4)	
	10-12	175	Grade 4-6: Girls	40.2 (5.1)	38.3 (5.8)	
Cliff et al.	3-5	25	Boys	20.24 (7.72)	20.60 (6.14)	
	3-5	21	Girls	26.38 (7.5)	22.0 (6.8)	
Crane et al.	5-6	124	Boys	25.8 (7.1)	23.6 (8.0)	
	5-6	126	Girls	26.9 (6.8)	19.8 (6.5)	
Field & Temple	9.5	195	Boys	32.6 (4.5)	35.6 (5.5)	
	9.5	205	Girls	33.3 (4.5)	28.6 (5.8)	
Freitas et al.	7 (7.5 ± 0.3)	48	Boys	34.7 (5.1)	31.7 (5.8)	
	7 (7.5 ± 0.3)	45	Girls	36.0 (4.1)	28.6 (6.2)	
	8 (8.5 ± 0.3)	51	Boys	37.5 (3.8)	35.9 (4.1)	
	8 (8.5 ± 0.3)	41	Girls	37.8 (4.0)	29.0 (5.3)	
	9 (9.5 ± 0.3)	45	Boys	39.2 (5.6)	37.0 (5.8)	
	9 (9.4 ± 0.3)	52	Girls	38.2 (3.9)	32.3 (4.7)	
	10 (10.6 ± 0.3)	69	Boys	39.3 (4.7)	39.9 (4.6)	
	10 (10.6 ± 0.3)	78	Girls	40.0 (4.1)	34.7 (5.8)	
Hall et al.	3-5 (M: 4.28 ± 0.74)	166		26.80 (7.60)	18.93 (8.30)	45.73 (12.07)
	3-5	91	Boys	26.10 (8.01)	19.53 (9.04)	45.73 (13.01)
	3-5	75	Girls	27.80 (6.95)	18.08 (7.13)	45.88 (10.75)
Invernessi et al.	10.5 ± 0.5	62	INT	40.1 (0.9)	35.5 (1.2)	75.6 (14.5)
	10.5 ± 0.5	59	CON	41.0 (1.1)	37.9 (1.3)	79.0 (2.2)
Khodaverdi et al.	8-9 (8.78 ± 0.32)	352	Girls	41.92 (6.57)	34.34 (5.51)	
Kim et al.	3-10 (6.8 ± 1.9)	139		36.82 (9.08)	31.33 (9.63)	
Kit et al.	3-5	330		28.2 (0.5)	21.0 (0.3)	
	3-5	167	Boys	26.8 (0.9)	22.8 (0.6)	
	3-5	163	Girls	29.7 (0.6)	19.2 (0.6)	
	3	100		20.5 (1.2)	15.7 (0.7)	
	4	112		29.7 (0.7)	20.4 (0.7)	
	5	118		33.6 (0.8)	26.6 (0.9)	
Korbecki et al.	6	64		31.55 (5.85)	27.22 (6.95)	
	6	29	Girls	30.14 (5.93)	23.21 (5.47)	
	6	35	Boys	32.69 (5.61)	30.54 (6.30)	
	7	34		33.41 (6.00)	31.24 (5.20)	
	7	14	Girls	34.07 (5.88)	29.07 (4.39)	
	7	20	Boys	32.95 (6.19)	32.75 (5.28)	
Kordi et al.	4-6 (4.95 ± 0.83)	147		29.7 (11.2)	25.4 (9.4)	
	4-6	75	Boys	29.5 (11.1)	26.0 (9.3)	
	4-6	72	Girls	30.0 (11.5)	24.8 (9.5)	
	3		Boys	18 (12.5)	22.0 (12.8)	
	3		Girls	3.0 (1.4)	12.0 (5.7)	
	4		Boys	21.5 (13.2)	24.2 (8.9)	
	4		Girls	28.3 (13.0)	24.6 (11.1)	
	5		Boys	31.4 (10.1)	26.2 (9.5)	
	5		Girls	31.8 (10.0)	26.4 (9.5)	
	6		Boys	33.7 (6.5)	27.5 (8.7)	
	6		Girls	31.9 (8.5)	23.4 (6.4)	
LeGear et al.	5.75	135	Boys	25.07 (7.38)	22.53 (7.98)	47.60 (13.86)
	5.75	125	Girls	26.87 (7.24)	19.25 (6.06)	46.12 (11.11)
Lin & Yang	6-7	92		23.49 (5.41)	27.41 (6.52)	50.90 (9.02)
	7-8	197		25.34 (5.12)	28.25 (6.15)	53.59 (8.50)

	8-9	196		26.74 (5.32)	30.77 (5.82)	57.52 (8.85)
	6-9	244	Boys	25.36 (5.57)	31.48 (5.67)	56.84 (8.70)
	6-9	241	Girls	25.76 (5.19)	26.71 (5.88)	52.47 (8.95)
Liong et al.	5-8	66	Girls	32.2 (5.3)	26.7 (6.5)	58.9 (10.5)
	5-8	69	Boys	30.2 (5.7)	32.3 (8.1)	62.4 (11.3)
	5-8 (6.5 ± 1.1)	135		31.2 (5.6)	29.6 (7.8)	60.7 (11.0)
Miklánková	5.8 ± 0.38	62		43.23 (6.34)	31.89 (8.73)	
Mukherjee et al.	6-0 to 6-5 (6.34 ± 0.07)	13	Girls	34.00 (4.20)	19.31 (4.33)	
	6-0 to 6-5 (6.32 ± 0.07)	12	Boys	35.33 (5.43)	25.08 (6.35)	
	6-6 to 6-11 (6.70 ± 0.14)	38	Boys	35.18 (5.84)	26.87 (6.01)	
	6-6 to 6-11 (6.71 ± 0.15)	32	Girls	34.97 (4.98)	24.16 (4.97)	
	7-0 to 7-5 (7.04 ± 0.06)	15	Girls	35.07 (6.04)	22.07 (4.80)	
	7-0 to 7-5 (7.04 ± 0.05)	10	Boys	36.10 (4.53)	24.80 (5.22)	
	8-0 to 8-11 (8.79 ± 0.09)	14	Girls	37.86 (4.83)	29.43 (4.57)	
	8-0 to 8-11(8.79 ± 0.10)	21	Boys	37.14 (5.31)	33.81 (4.90)	
	9-0 to 9-11 (9.30 ± 0.21)	51	Boys	37.86 (4.88)	33.61 (3.81)	
	9-0 to 9-11 (9.29 ± 0.21)	38	Girls	38.68 (4.59)	30.16 (5.11)	
Palmer & Brian	4.88 ± 0.28	43	Expert Coder	19	15.5	
	4.88 ± 0.28	43	Novice Coders	28.12	22.6	
Pang & Fong	6-0 to 6-5	15	Boys	43.8 (2.5)	38.6 (4.7)	
	6-0 to 6-5	9	Girls	44.1 (3.5)	35.7 (6.1)	
	6-6 to 6-11	12	Boys	43.4 (2.5)	41.3 (4.3)	
	6-6 to 6-11	10	Girls	43.9 (1.8)	37.8 (6.3)	
	7-0 to 7-5	15	Boys	44.6 (2.5)	43.2 (4.0)	
	7-0 to 7-5	21	Girls	43.6 (1.8)	38.9 (3.6)	
	7-6 to 7-11	13	Boys	44.7 (2.7)	44.5 (2.7)	
	7-6 to 7-11	8	Girls	43.5 (2.0)	41.0 (4.9)	
	8-0 to 8-11	28	Boys	44.9 (2.5)	44.6 (2.1)	
	8-0 to 8-11	28	Girls	45.0 (2.6)	42.5 (3.0)	
	9-0 to 9-11	8	Boys	45.5 (2.6)	44.0 (3.3)	
Rechtik	5.9 ± 1.63	132		34.03 (10.03)	30.60 (9.41)	
	5.9 ± 1.63	102	Boys	33.33 (9.57)	30.89 (9.83)	
	5.9 ± 1.63	130	Girls	34.57 (10.38)	30.37 (9.10)	
Robinson et al.	4.75 ± 0.53	34		30.20 (7.43)	32.82 (8.54)	
	4.77 ± 0.66	12	Boys	31.66 (9.91)	37.58 (9.90)	
	4.74 ± 0.46	22	Girls	29.4 (5.79)	30.22 (6.58)	
Rudd et al.	6-8	24	Boys	32.9 (5.3)	34.2 (5.9)	
	6-8	21	Girls	35.9 (4.7)	30.3 (4.7)	
	8-10	31	Boys	35.8 (3.8)	37.3 (4.6)	
	8-10	26	Girls	37.3 (4.6)	35.0 (3.9)	
	10-12	31	Boys	36.4 (5.3)	41.3 (4.3)	
	10-12	25	Girls	35.4 (4.3)	35.2 (4.7)	
	6-12 (9.5 ± 2.2)	86	Boys	35.2 (5.0)	37.9 (5.6)	
	6-12 (9.5 ± 2.2)	72	Girls	35.1 (4.4)	33.7 (4.9)	
Rudd et al.	6-10 (M: 8.1 ± 1.1)	69	INT: Boys	28.3 (6.3)	30.0 (8.5)	
	6-10 (M: 8.1 ± 1.1)	66	INT: Girls	31.0 (6.1)	27.0 (7.0)	
	6-10 (M: 8.1 ± 1.1)	102	CON: Boys	28.0 (7.2)	32.0 (7.8)	
	6-10 (M: 8.1 ± 1.1)	96	CON: Girls	30.4 (5.9)	26.6 (7.4)	
Slykerman et al.	5-8 (6.5 ± 1.0)	109		31.2 (5.6)	29.5 (8.1)	
	5-8 (6.5 ± 1.0)	59	Boys	30.4 (5.4)	32.1 (8.3)	
	5-8 (6.5 ± 1.0)	50	Girls	32.0 (5.8)	26.4 (6.7)	
Spessato et al.	4	48				35.50 (12.37)
	5	58				43.81 (6.73)
	6	40				50.00 (9.44)
	7	32				59.62 (9.02)
	4-7 (5.36 ± 1.0)	178				45.80 (12.56)
Valentini	3	42	Girls	18.3 (6.91)	13.69 (4.04)	
	3	52	Boys	18.60 (7.5)	15.88 (4.89)	
	4	62	Girls	23.47 (6.88)	17.24 (4.88)	
	4	61	Boys	23.61 (6.53)	21.90 (5.64)	
	5	112	Girls	26.20 (7.16)	17.78 (7.16)	
	5	108	Boys	28.10 (6.83)	24.94 (8.17)	
	6	186	Girls	28.07 (6.57)	20.76 (7.49)	
	6	173	Boys	29.09 (6.83)	27.58 (7.73)	
	7	190	Girls	29.51 (7.45)	24.11 (7.18)	
	7	222	Boys	31.13 (7.76)	31.97 (7.35)	

	8	292	Girls	29.23 (6.69)	26.75 (5.90)	
	8	285	Boys	31.32 (6.69)	34.42 (6.28)	
	9	271	Girls	30.31 (6.62)	28.44 (5.90)	
	9	266	Boys	30.88 (6.85)	35.25 (6.07)	
	10	167	Girls	31.16 (6.35)	29.67 (6.10)	
	10	185	Boys	31.99 (6.74)	36.82 (6.24)	
	3-10	1322	Girls	28.70 (7.25)	24.62 (7.68)	
	3-10	1352	Boys	29.91 (7.54)	31.60 (8.50)	
	3-10 (7.56 ± 1.91)	2674		29.48 (6.13)	27.00 (8.02)	56.49 (12.42)
Wong & Cheung	3	50	Boys	20.58 (6.78)	12.94 (6.45)	
	3	65	Girls	23.65 (5.89)	12.28 (6.45)	
	4	134	Boys	28.90 (9.43)	17.54 (6.27)	
	4	111	Girls	27.63 (8.78)	14.72 (5.07)	
	5	152	Boys	33.59 (6.48)	22.97 (7.61)	
	5	118	Girls	34.05 (6.09)	17.99 (5.45)	
	6	88	Boys	36.02 (5.05)	27.44 (6.71)	
	6	79	Girls	36.80 (6.32)	22.63 (6.23)	
	7	58	Boys	41.05 (4.35)	30.45 (5.69)	
	7	69	Girls	41.10 (4.06)	27.22 (5.64)	
	8	51	Boys	42.00 (2.95)	36.29 (5.36)	
	8	38	Girls	42.34 (3.06)	28.39 (6.66)	
	9	68	Boys	43.43 (3.18)	35.54 (6.65)	
	9	40	Girls	42.63 (3.69)	30.10 (5.23)	
	10	74	Boys	43.78 (2.48)	34.51 (8.75)	
	10	33	Girls	42.97 (3.31)	29.03 (5.22)	
Yang et al.	3-7 (5.1 ± 0.83)	516	Boys	22.08 (5.99)	22.60 (6.36)	42.68 (10.68)
	3-7 (5.1 ± 0.83)	613	Girls	22.45 (5.77)	20.29 (5.74)	42.75 (9.79)
	3-4	104		18.00 (5.98)	17.22 (4.50)	35.22 (8.54)
	4-5	331		20.76 (5.70)	19.44 (5.25)	40.20 (9.23)
	5-6	357		23.64 (5.45)	22.58 (5.56)	46.23 (9.22)
	6-7	237		24.17 (5.23)	24.41 (6.87)	48.57 (9.97)
Zuvela et al.	8 (M: 8.1 ± 0.3)	95				59.45 (15.25)

LM: Locomotor; OC: Object Control

M: Mean

INT: Intervention group; EXP: Experimental group; CON: Control group

Table 3. Summary of the results of studies that reported raw skill scores based on the TGMD-2

Author	Age	n	Group	Run	Gallop	Hop	Leap	Jump	Slide	Strike	Dribble	Catch	Kick	Throw	Roll
Antunes et al.	6 (6.72 ± 0.2)	27	Boys	5.9 (1.7)		6.4 (1.9)	2.5 (1.2)				5.0 (2.3)		5.0 (1.3)		
	6 (6.64 ± 0.2)	23	Girls		5.1 (3.0)										
	7 (7.58 ± 0.2)	28	Girls		6.4 (2.4)										
	7 (7.62 ± 0.2)	29	Boys	7.2 (1.5)		7.0 (1.6)	2.0 (1.3)				6.4 (2.3)		4.5 (2.0)		
	8 (8.59 ± 0.3)	27	Boys	7.5 (0.9)		7.1 (1.5)	2.6 (1.0)				7.3 (1.3)		5.1 (1.0)		
	8 (8.68 ± 0.3)	24	Girls		7.5 (1.1)										
Aye et al.	5 (M: 5.43 ± 0.35)	237	Boys	7.08 (1.54)	6.52 (2.34)	8.81 (2.20)	4.00 (1.82)	5.18 (2.28)	7.18 (1.84)	7.53 (2.18)	2.37 (3.15)	3.58 (1.77)	7.47 (1.27)	5.68 (2.23)	5.16 (1.98)
	5 (M: 5.39 ± 0.33)	235	Girls	6.66 (1.89)	7.15 (1.86)	8.63 (2.55)	3.88 (1.63)	5.12 (1.96)	7.18 (1.57)	6.59 (2.22)	1.79 (2.81)	3.39 (1.81)	6.79 (1.79)	4.73 (2.41)	4.56 (1.52)
	5 (M: 5.41 ± 0.34)	472		6.87 (1.74)	6.83 (2.13)	8.72 (2.38)	3.94 (1.73)	5.15 (2.13)	7.18 (1.72)	7.06 (2.25)	2.08 (2.99)	3.49 (1.79)	7.13 (1.59)	5.21 (2.37)	4.86 (1.79)
Aye et al.	5 (M: 5.70 ± 0.31)	60		7.72 (0.76)	6.55 (2.24)	8.38 (2.11)	3.17 (1.29)	5.62 (2.02)	7.07 (1.76)	8.22 (1.58)	6.23 (2.68)	4.00 (1.29)	7.22 (1.46)	5.73 (1.95)	4.98 (1.80)
	5 (M: 5.66 ± 0.30)	34	Boys	7.71 (0.84)	6.03 (2.56)	7.79 (2.43)	2.97 (1.31)	5.38 (2.06)	6.71 (2.18)	8.65 (1.52)	6.18 (2.77)	4.00 (1.21)	7.68 (0.88)	6.18 (1.98)	5.15 (1.96)
	5 (M: 5.76 ± 0.32)	26	Girls	7.73 (0.67)	7.23 (1.50)	9.15 (1.26)	3.42 (1.24)	5.92 (1.96)	7.54 (0.81)	7.65 (1.52)	6.31 (2.62)	4.00 (1.41)	6.62 (1.83)	5.15 (1.78)	4.77 (1.58)
Bardid et al.	3	113	Girls	3.8 (1.7)	4.7 (2.3)	2.7 (3.3)	2.7 (2.0)	4.1 (2.2)	2.5 (2.7)	3.7 (2.5)	0.5 (1.1)	1.8 (1.4)	3.2 (1.7)	1.8 (1.5)	3.1 (1.6)
	3	121	Boys	4.2 (2.0)	3.6 (2.5)	1.9 (2.5)	3.0 (2.0)	4.0 (2.1)	3.0 (2.8)	4.8 (2.6)	0.7 (1.5)	2.0 (1.5)	3.9 (1.8)	2.5 (1.8)	3.6 (1.9)
	3	234		4.0 (1.9)	4.1 (2.4)	2.3 (2.9)	2.9 (2.0)	4.0 (2.1)	2.7 (2.8)	4.3 (2.6)	0.6 (1.3)	1.9 (1.4)	3.6 (1.8)	2.2 (1.7)	3.3 (1.8)
	4	159	Girls	5.3 (1.8)	5.4 (2.3)	6.2 (2.7)	3.6 (1.6)	4.5 (2.0)	4.7 (2.7)	5.1 (2.2)	1.2 (1.7)	2.1 (1.5)	3.5 (1.6)	2.5 (1.9)	3.8 (1.7)
	4	215	Boys	5.3 (1.9)	4.9 (2.3)	4.9 (3.0)	3.7 (1.7)	4.5 (2.1)	4.7 (2.7)	5.5 (2.2)	1.6 (2.0)	2.7 (1.5)	4.8 (1.9)	3.5 (2.2)	4.3 (1.8)
	4	374		5.3 (1.9)	5.1 (2.3)	5.5 (3.0)	3.7 (1.7)	4.5 (2.0)	4.7 (2.7)	5.3 (2.2)	1.4 (1.9)	2.4 (1.5)	4.2 (1.9)	3.1 (2.1)	4.1 (1.8)
	5	149	Girls	5.9 (1.9)	6.0 (1.7)	7.3 (1.8)	4.0 (1.6)	5.4 (1.9)	5.8 (2.5)	6.1 (2.3)	1.8 (2.0)	3.2 (1.5)	4.2 (1.6)	3.4 (2.1)	4.6 (1.7)
	5	181	Boys	6.0 (1.8)	5.6 (2.0)	6.7 (2.3)	4.2 (1.6)	5.4 (2.0)	5.7 (2.5)	6.7 (2.3)	2.9 (2.6)	3.4 (1.6)	5.5 (1.7)	4.4 (2.2)	4.6 (1.8)
	5	330		5.9 (1.8)	5.8 (1.9)	7.0 (2.1)	4.1 (1.6)	5.4 (1.9)	5.7 (2.5)	6.4 (2.3)	2.4 (2.4)	3.3 (1.6)	4.9 (1.8)	3.9 (2.2)	4.6 (1.7)
	6	164	Girls	6.2 (1.9)	6.2 (1.8)	8.2 (1.6)	4.3 (1.4)	5.6 (1.8)	6.6 (2.1)	6.4 (2.2)	3.2 (2.6)	3.7 (1.7)	4.8 (1.8)	3.6 (1.9)	4.9 (1.7)
	6	159	Boys	6.4 (1.8)	5.8 (2.0)	8.0 (1.6)	4.3 (1.4)	5.4 (1.9)	6.5 (2.0)	6.9 (2.3)	5.1 (2.6)	4.3 (1.5)	6.2 (1.6)	5.3 (1.9)	5.4 (1.5)
	6	323		6.3 (1.9)	6.0 (1.9)	8.1 (1.6)	4.3 (1.4)	5.5 (1.8)	6.6 (2.0)	6.6 (2.3)	4.1 (2.7)	4.0 (1.6)	5.5 (1.9)	4.4 (2.1)	5.1 (1.6)
	7	107	Girls	6.5 (1.5)	6.2 (1.7)	8.4 (1.5)	4.6 (1.5)	5.8 (1.7)	7.0 (1.8)	6.4 (2.1)	4.6 (2.4)	4.3 (1.6)	4.6 (1.7)	4.7 (2.1)	5.0 (1.6)
	7	103	Boys	6.5 (1.6)	6.4 (1.5)	8.2 (1.6)	4.3 (1.4)	5.8 (1.9)	7.1 (1.5)	8.1 (2.0)	6.0 (2.2)	4.6 (1.4)	6.2 (1.8)	5.8 (1.9)	5.7 (1.6)
	7	210		6.5 (1.5)	6.3 (1.6)	8.3 (1.5)	4.4 (1.4)	5.8 (1.8)	7.0 (1.6)	7.2 (2.2)	5.3 (2.4)	4.4 (1.5)	5.4 (1.9)	5.3 (2.1)	5.4 (1.6)
	8	81	Girls	6.1 (1.6)	6.3 (1.5)	8.2 (1.5)	4.8 (1.2)	6.1 (1.9)	7.0 (1.7)	6.8 (2.2)	5.6 (2.2)	4.8 (1.3)	4.7 (1.6)	4.8 (2.1)	5.7 (1.6)
	8	62	Boys	6.8 (1.4)	6.4 (1.7)	8.5 (1.5)	4.5 (1.6)	6.2 (1.8)	7.2 (1.7)	7.6 (2.2)	6.6 (1.7)	5.0 (1.2)	6.6 (1.4)	6.3 (1.7)	6.0 (1.6)
	8	143		6.4 (1.6)	6.3 (1.5)	8.3 (1.5)	4.7 (1.4)	6.2 (1.8)	7.1 (1.7)	7.1 (2.3)	6.0 (2.0)	4.9 (1.3)	5.5 (1.8)	5.5 (2.1)	5.8 (1.6)
Butterfield et al.	6	7	Boys							7.14 (3.44)		5.00 (0.82)	6.17 (1.33)	3.14 (2.67)	
	6	10	Girls							7.40 (2.12)		4.50 (1.78)	5.40 (1.90)	2.90 (3.14)	
	7	9	Boys							8.44 (2.19)		5.33 (0.71)	6.22 (1.30)	6.00 (2.60)	
	7	12	Girls							7.58 (1.88)		4.92 (0.90)	5.92 (1.44)	3.08 (2.84)	
	8	8	Boys							9.25 (0.89)		5.63 (0.52)	7.38 (0.92)	6.00 (3.70)	

	8	5	Girls							7.80 (1.92)		5.00 (0.71)	7.20 (1.10)	6.40 (0.89)	
	9	9	Boys							9.56 (0.88)		5.67 (0.50)	7.56 (0.73)	8.00 (0.00)	
	9	8	Girls							6.50 (2.33)		5.50 (0.76)	6.63 (1.41)	3.25 (2.60)	
	10	14	Boys							9.21 (0.70)		6.00 (0.00)	7.50 (1.16)	7.43 (1.22)	
	10	11	Girls							9.55 (0.82)		5.82 (0.40)	7.73 (0.65)	7.09 (2.43)	
	11	17	Boys							9.88 (0.49)		6.00 (0.00)	7.88 (0.49)	7.53 (0.87)	
	11	11	Girls							9.27 (1.10)		5.73 (0.65)	7.27 (0.90)	6.73 (1.01)	
	12	10	Boys							9.80 (0.42)		5.90 (0.32)	7.50 (0.85)	7.30 (1.34)	
	12	7	Girls							9.14 (1.21)		6.00 (0.00)	7.57 (0.79)	6.57 (1.62)	
	13	16	Boys							9.00 (1.21)		5.75 (0.58)	7.75 (0.58)	7.56 (0.81)	
	13	5	Girls							9.60 (0.55)		6.00 (0.00)	7.80 (0.45)	6.80 (1.79)	
	6-13 (10.0 ± 2.4)	96	Boys							9.16 (1.56)		5.72 (0.56)	7.38 (1.03)	6.77 (2.29)	
	6-13 (9.1 ± 2.5)	75	Girls							8.17 (2.05)		5.35 (1.01)	6.73 (1.55)	5.12 (2.92)	
	6-13 (9.6 ± 2.5)	186								8.78 (2.01)		5.56 (0.81)	7.53 (5.80)	6.05 (2.71)	
Capio et al.	8-12 (8.6 ± 0.68)	20	ER: Low											6.30 (1.59)	
	8-12 (8.67 ± 0.59)	34	ES: Low											6.53 (1.64)	
	8-12 (9.27 ± 0.91)	55	ES: Mid											7.38 (0.91)	
	8-12 (9.34 ± 0.76)	53	ER: Mid											7.57 (1.06)	
	8-12 (9.53 ± 0.96)	28	ES: High											7.14 (1.51)	
	8-12 (9.81 ± 0.98)	26	ER: High											7.27 (0.96)	
Crane et al.	5-6 (M: 5.8 ± 0.3)	124	Boys	5.6 (1.8)	3.6 (2.2)	4.7 (1.9)	3.2 (1.3)	3.5 (2.2)	5.0 (2.4)	6.4 (2.0)	2.4 (2.3)	3.2 (1.5)	5.1 (1.6)	3.1 (2.4)	3.1 (2.0)
	5-6 (M: 5.8 ± 0.3)	126	Girls	5.3 (1.9)	4.2 (2.1)	5.0 (1.9)	2.8 (1.9)	3.3 (2.1)	5.3 (2.3)	5.2 (2.0)	2.2 (2.1)	3.1 (1.5)	4.4 (1.6)	1.8 (1.3)	3.7 (1.3)
Du Plessis et al.	6-7 (M: 6.84 ± 0.39)	806	Grade 1							6.78 (1.84)	4.17 (2.42)	4.70 (1.12)	6.07 (1.42)	2.88 (2.34)	4.36 (1.87)
Freitas et al.	7 (7.5 ± 0.3)	48	Boys	7.0 (1.6)	6.0 (2.3)	6.7 (1.4)	2.2 (1.3)	5.4 (2.3)	7.5 (1.2)	6.1 (1.7)	6.0 (2.2)	4.3 (1.4)	4.5 (1.6)	4.9 (2.1)	6.0 (1.5)
	7 (7.5 ± 0.3)	45	Girls	7.0 (1.1)	6.4 (2.4)	6.9 (2.0)	2.4 (1.3)	5.4 (1.7)	7.9 (0.7)	5.4 (2.2)	5.6 (2.2)	4.1 (1.4)	3.8 (1.6)	4.1 (2.0)	5.6 (1.8)
	8 (8.5 ± 0.3)	51	Boys	7.3 (1.1)	7.0 (1.8)	7.1 (1.6)	2.4 (1.0)	5.7 (1.8)	8.0 (0.1)	7.1 (1.6)	7.2 (1.4)	4.6 (1.3)	5.1 (1.1)	5.7 (1.5)	6.3 (1.3)
	8 (8.5 ± 0.3)	41	Girls	7.0 (1.2)	7.2 (1.6)	7.3 (1.6)	2.9 (1.4)	5.4 (1.9)	8.0 (0.2)	5.3 (1.6)	6.1 (2.1)	4.3 (1.2)	3.9 (1.3)	4.0 (2.4)	5.4 (1.6)
	9 (9.5 ± 0.3)	45	Boys	7.3 (1.3)	7.6 (1.4)	7.7 (2.0)	2.6 (1.4)	6.2 (1.5)	7.8 (0.8)	7.2 (2.7)	7.4 (1.2)	5.2 (0.9)	5.2 (1.6)	5.9 (1.5)	6.0 (1.9)
	9 (9.4 ± 0.3)	52	Girls	6.9 (1.4)	7.4 (1.6)	7.4 (1.5)	2.7 (1.2)	5.9 (1.6)	7.9 (0.6)	5.9 (1.8)	7.0 (1.4)	4.9 (1.1)	4.4 (1.0)	4.2 (1.8)	6.0 (1.7)
	10 (10.6 ± 0.3)	69	Boys	7.3 (1.2)	7.4 (1.3)	8.0 (1.7)	3.1 (1.7)	5.6 (1.6)	7.9 (0.5)	7.7 (1.9)	7.4 (1.1)	5.5 (0.9)	6.2 (1.8)	6.2 (1.3)	6.9 (1.4)
	10 (10.6 ± 0.3)	78	Girls	7.4 (1.2)	7.6 (1.0)	8.4 (1.5)	2.8 (1.7)	5.9 (1.7)	7.9 (0.5)	6.2 (2.4)	7.1 (1.3)	5.6 (0.8)	4.9 (2.1)	4.9 (1.9)	6.1 (1.8)
Hardy et al.	4.0-4.9	159	Girls	7.34 (0.13)	5.06 (0.33)	6.32 (0.39)		4.92 (0.33)		6.00 (0.19)		3.97 (0.14)	5.21 (0.29)	3.13 (0.29)	
	4.0-4.9	171	Boys	7.44 (0.01)	4.38 (0.44)	5.02 (0.44)		4.55 (0.25)		7.08 (0.18)		4.06 (0.15)	6.14 (0.24)	3.92 (0.25)	
Kim et al.	3-10 (6.8 ± 1.9)	139		6.53 (1.77)	5.50 (2.00)	7.60 (2.91)	4.83 (1.44)	5.50 (2.38)	6.86 (1.71)	6.88 (2.64)	3.12 (2.76)	5.32 (1.55)	5.70 (1.92)	5.20 (2.52)	5.12 (2.41)
Korbecki et al.	6	64		5.68 (1.75)	5.50 (1.29)	6.10 (2.21)	4.15 (1.52)	4.82 (2.10)	5.44 (1.36)	5.63 (2.27)	3.01 (2.06)	4.28 (1.57)	5.57 (1.71)	4.16 (2.13)	4.82 (1.73)
	6	29	Girls	5.42 (1.59)	5.32 (1.05)	6.39 (2.12)	3.52 (1.50)	4.35 (2.40)	5.39 (1.48)	4.45 (1.77)	2.61 (1.73)	4.32 (1.56)	4.84 (1.63)	2.68 (1.38)	4.42 (1.75)
	6	35	Boys	5.89 (1.87)	5.65 (1.46)	5.86 (2.29)	4.68 (1.33)	5.21 (1.75)	5.49 (1.28)	6.62 (2.18)	3.35 (2.26)	4.24 (1.42)	6.19 (1.54)	5.41 (1.85)	5.16 (1.66)

	7	34		6.07 (1.93)	5.50 (1.14)	6.03 (2.50)	4.43 (1.38)	5.53 (1.87)	5.40 (1.57)	5.80 (1.86)	4.20 (2.28)	4.80 (1.16)	5.90 (1.45)	4.90 (2.09)	5.70 (1.56)
	7	14	Girls	6.42 (1.98)	5.58 (1.17)	6.42 (2.75)	4.25 (1.14)	6.08 (1.44)	5.33 (1.56)	5.33 (2.27)	5.00 (2.09)	5.17 (0.83)	5.00 (1.04)	3.75 (1.82)	5.42 (1.68)
	7	20	Boys	5.83 (1.92)	5.44 (1.15)	5.78 (2.37)	4.56 (1.54)	5.17 (2.07)	5.44 (1.62)	6.11 (1.53)	3.67 (2.30)	4.56 (1.29)	6.50 (1.38)	5.67 (1.94)	5.89 (1.49)
Lin & Yang	6-7	92		6.57 (1.42)	2.86 (1.92)	4.89 (2.53)	4.65 (1.09)	3.01 (1.81)	1.51 (2.15)	5.80 (2.14)	4.08 (1.95)	3.23 (1.44)	6.25 (1.63)	4.24 (2.35)	3.82 (2.03)
	7-8	197		6.95 (1.19)	3.33 (1.90)	4.34 (2.31)	4.74 (1.10)	4.14 (2.10)	1.85 (2.42)	5.47 (2.52)	4.17 (2.04)	3.47 (1.32)	6.19 (1.71)	5.01 (2.40)	3.93 (2.08)
	8-9	196		7.51 (0.81)	3.05 (1.65)	4.43 (2.10)	4.95 (1.08)	4.07 (2.09)	2.73 (2.81)	5.74 (2.52)	4.80 (2.14)	3.96 (1.29)	6.53 (1.78)	5.64 (2.16)	4.10 (2.18)
	6-9	244	Boys	7.06 (1.17)	3.05 (1.79)	4.36 (2.18)	4.80 (1.09)	3.83 (2.06)	2.25 (2.64)	6.48 (2.40)	4.62 (2.13)	3.73 (1.33)	6.47 (1.82)	5.80 (2.31)	4.38 (2.11)
	6-9	241	Girls	7.15 (1.16)	3.20 (1.84)	4.60 (2.37)	4.81 (1.11)	3.96 (2.11)	2.03 (2.52)	4.80 (2.21)	4.19 (2.02)	3.51 (1.38)	6.21 (1.63)	4.44 (2.19)	3.57 (2.03)
Miller et al.	10-12 (M: 11.12 ± 1.28)	97	INT									3.56 (1.10)	4.98 (1.99)	2.10 (1.83)	
	10-12 (M: 11.20 ± 0.61)	71	CON									3.91 (0.90)	5.38 (1.85)	2.33 (2.15)	
Palmer & Brian	4-5 (M: 4.88 ± 0.28)	43	Expert	5	2.6	4.3	2.8	2.3	2	3.5	0.8	3.7	3.3	1.6	2.6
	4-5 (M: 4.88 ± 0.28)	43	Novice	5.8	3.4	5.7	4.1	3.7	5.42	5.8	1.7	4.5	3.8	3.3	3.5
Pienaar et al.	9-10 (M: 9.9 ± 0.46)	433	Boys							8.96 (1.42)	7.09 (1.42)	5.76 (0.67)	7.63 (0.76)	6.55 (1.53)	6.41 (1.44)
	9-10 (M: 9.9 ± 0.46)	393	Girls							8.37 (1.58)	6.70 (1.72)	5.78 (0.55)	7.12 (1.16)	6.14 (1.64)	6.03 (1.45)
	9-10 (M: 9.9 ± 0.63)	826								8.68 (1.53)	6.91 (1.58)	5.77 (0.62)	7.39 (1.00)	6.36 (1.59)	6.23 (1.46)
Valentini	3-10 (M: 7.56 ± 1.91)	2674		6.24 (1.81)	5.20 (1.84)	5.22 (1.86)	4.05 (1.41)	3.26 (1.83)	5.46 (2.54)	5.89 (2.28)	3.99 (2.87)	4.23 (1.68)	4.13 (1.99)	3.99 (2.36)	4.18 (2.20)
Wong & Cheung	3-10 (M: 6.49 ± 2.10)	614		7.12 (1.33)	5.98 (2.45)	5.41 (2.66)	4.21 (2.02)	6.69 (1.71)	5.50 (2.67)	5.37 (2.99)	4.49 (2.71)	2.35 (1.69)	5.27 (2.62)	2.99 (2.00)	3.14 (1.90)
Yang et al.	3-7 (M: 5.1 ± 0.83)	516	Boys	6.61 (1.49)	2.36 (1.20)	3.96 (2.14)	4.53 (1.47)	2.94 (1.86)	1.68 (2.22)	4.40 (2.10)	2.41 (2.06)	2.87 (1.31)	6.28 (1.72)	3.50 (1.98)	3.13 (1.92)
	3-7 (M: 5.1 ± 0.83)	613	Girls	6.50 (1.23)	2.59 (1.35)	4.32 (2.20)	4.32 (1.65)	3.00 (1.98)	1.72 (2.21)	3.84 (1.96)	2.19 (1.98)	2.66 (1.23)	5.77 (1.65)	2.97 (1.74)	2.85 (1.80)
	3-4	104		6.17 (1.82)	1.87 (0.71)	2.66 (2.46)	3.63 (1.96)	2.44 (1.65)	1.23 (1.77)	3.26 (1.56)	1.07 (1.26)	2.18 (1.12)	5.75 (1.76)	2.82 (1.46)	2.14 (1.65)
	4-5	331		6.52 (1.38)	2.29 (1.15)	3.48 (2.09)	4.03 (1.72)	2.87 (1.85)	1.57 (2.15)	3.66 (1.91)	1.69 (1.66)	2.55 (1.19)	6.07 (1.56)	2.77 (1.64)	2.70 (1.77)
	5-6	357		6.66 (1.19)	2.67 (1.37)	4.55 (2.02)	4.78 (1.33)	3.05 (1.99)	1.93 (2.29)	4.48 (2.03)	2.56 (2.02)	2.91 (1.24)	5.97 (1.74)	3.51 (1.87)	3.15 (1.85)
	6-7	237		6.62 (1.33)	2.73 (1.39)	5.08 (1.72)	4.79 (1.16)	3.21 (1.95)	1.74 (2.31)	4.61 (2.22)	3.33 (2.19)	3.11 (1.37)	6.16 (1.82)	3.66 (2.18)	3.53 (1.93)

M: Mean

ER: Error-reduced training group; ES: Error-strewn training group

INT: Intervention group; CON: Control group;

Expert: Expert Coder; Novice: Novice Coders

Table 4. Summary of the results of studies that reported SS, GMQ, percentile and/or age equivalent scores based on the TGMD-2

Author	Age	n	Group	SS			GMQ	Mean Percentile			Age Equivalent	
				LM	OC	Total		LM	OC	GMQ	LM	OC
Adamo et al.	3-5 (M: 3.4 ± 0.3)	36	INT	9.80 (0.76)	9.16 (0.57)		96.76 (3.97)	48.42 (8.51)	39.54 (6.45)	42.04 (9.16)		
	3-5 (M: 3.4 ± 0.4)	39	CON	10.30 (0.75)	9.39 (0.57)		98.99 (3.94)	53.26 (8.44)	42.43 (6.38)	47.85 (9.10)		
Aye et al.	5 (M: 5.43 ± 0.35)	237	Boys	12.90 (3.74)	10.00 (2.65)	22.90 (5.02)	108.30 (16.30)	71.70 (29.00)	49.20 (26.90)			
	5 (M: 5.39 ± 0.33)	235	Girls	12.60 (3.48)	10.20 (2.95)	22.80 (5.27)	108.40 (15.80)	71.30 (27.40)	50.50 (29.10)			
	5 (M: 5.41 ± 0.34)	472		12.80 (3.61)	10.10 (2.81)	22.90 (5.14)	108.30 (16.00)	71.50 (28.20)	49.80 (28.00)			
Aye et al.	5 (M: 5.70 ± 0.31)	60		11.70 (2.65)	12.00 (2.68)	23.70 (3.98)	111.10 (11.90)	66.70 (25.00)	68.80 (24.20)			
	5 (M: 5.66 ± 0.30)	34	Boys	11.00 (2.76)	11.70 (2.51)	22.60 (3.74)	107.90 (11.20)	58.90 (27.20)	65.80 (23.20)			
	5 (M: 5.76 ± 0.32)	26	Girls	12.70 (2.18)	12.40 (2.89)	25.10 (3.89)	115.40 (11.70)	76.80 (17.40)	72.70 (25.30)			
Bakhtiari et al.	9 (M: 8.9 ± 0.49)	20	EXP	3.30 (1.98)	5.05 (2.28)					65.20 (10.63)		
	9 (M: 8.9 ± 0.48)	20	CON	3.20 (1.32)	6.90 (2.35)					70.40 (8.04)		
Balaban	8-11.99	108	Boys				104.28 (12.03)					
	8-11.99	93	Girls				104.96 (11.71)					
	8-11.99 (M: 9.22 ± 1.04)	201					104.59 (11.90)					
Bardid et al.	3	113	Girls	9.60 (2.40)	8.90 (1.80)		95.40 (10.40)					
	3	121	Boys	9.20 (2.30)	8.90 (2.00)		94.40 (10.50)					
	3	234		9.40 (2.40)	8.90 (1.90)		94.90 (10.50)					
	4	159	Girls	10.60 (2.40)	8.20 (1.80)		96.30 (10.30)					
	4	215	Boys	10.00 (2.70)	8.70 (2.00)		96.10 (11.60)					
	4	374		10.20 (2.60)	8.50 (1.90)		96.20 (11.10)					
	5	149	Girls	10.30 (2.40)	8.20 (2.20)		95.50 (10.80)					
	5	181	Boys	10.00 (2.30)	8.40 (2.00)		95.40 (10.60)					
	5	330		10.20 (2.40)	8.30 (2.10)		95.50 (10.70)					
	6	164	Girls	9.50 (2.50)	7.80 (2.30)		91.90 (11.80)					
	6	159	Boys	9.40 (2.40)	8.30 (2.20)		93.00 (10.90)					
	6	323		9.50 (2.40)	8.00 (2.30)		92.50 (11.40)					
	7	107	Girls	9.00 (2.30)	7.40 (2.50)		89.10 (11.60)					
	7	103	Boys	8.70 (2.30)	7.70 (2.30)		89.00 (10.20)					
	7	210		8.80 (2.30)	7.50 (2.40)		89.10 (10.90)					
	8	81	Girls	7.80 (2.20)	7.00 (2.40)		84.30 (9.80)					
	8	62	Boys	8.50 (2.70)	7.10 (2.10)		86.80 (11.70)					

	8	143		8.10 (2.50)	7.10 (2.30)	85.40 (10.70)			
	3-8	773	Girls	9.60 (2.50)	8.00 (2.2)	92.90 (11.50)			
	3-8	841	Boys	9.50 (2.50)	8.40 (2.10)	93.60 (11.30)			
	3-8	1614		9.60 (2.50)	8.20 (2.20)	93.20 (11.40)			
Bolger et al.	6 (M: 5.9 ± 0.9)	52	Boys			97.70 (7.20)			
	6 (M: 6.0 ± 0.4)	50	Girls			100.90 (10.30)			
	10 (M: 10.0 ± 0.4)	58	Boys			87.50 (9.00)			
	10 (M: 9.8 ± 0.4)	43	Girls			92.30 (9.30)			
Brian et al.	3-6 (M: 4.39)	26	EXP		7.00 (1.8)			15.00 (1.90)	
	3-6 (M: 4.39)	31	CON		7.00 (1.70)			18.00 (2.40)	
Cepicka	7.1 ± 0.3	152	Boys				22.16 (17.00)	20.98 (17.22)	
	7.0 ± 0.3	163	Girls				35.29 (21.09)	23.60 (20.08)	
Chow & Chan	3-6 (M: 3.6 ± 0.2)	239					45.30 (26.00)	49.60 (28.40)	
Clark et al.	8-10	29	Boys				72.30 (7.47)	63.30 (15.20)	
	8-10	29	Girls				69.80 (5.27)	62.75 (10.50)	
Cliff et al.	3-5	25	Boys	7.92 (2.12)	8.60 (2.18)	88.24 (10.13)			
	3-5	21	Girls	9.86 (2.08)	10.05 (2.08)	99.71 (10.47)			
da Silva et al.	3.17-3.50	33	Boys				54.60 (4.90)	45.40 (4.90)	58.80 (10.90)
	3.17-3.50	39	Girls				55.90 (5.00)	44.00 (5.03)	53.30 (10.30)
de Meester et al.	6.92-11.83 (M: 9.5 ± 1.24)	361							18.97 (21.78)
	6.92-11.83	180	Boys						18.24 (20.66)
	6.92-11.83	181	Girls						19.69 (22.89)
Grant-Beuttler et al.	4 (M: 4.5 ± 0.4)	9		14.40 (2.90)	13.30 (1.90)	123.30 (9.90)			
	4	4	Boys	16.80 (3.30)	13.80 (1.00)	131.50 (7.10)			
	4	5	Girls	12.80 (1.30)	12.80 (2.60)	116.80 (6.20)			
	5 (M: 5.7 ± 0.2)	9		12.80 (2.50)	11.30 (2.20)	113.00 (10.40)			
	5	5	Boys	13.20 (3.40)	12.20 (1.30)	117.40 (9.80)			
	5	4	Girls	12.30 (1.30)	10.30 (2.90)	107.50 (9.30)			
	6 (M: 6.4 ± 0.2)	9		11.90 (3.50)	10.80 (2.80)	108.00 (17.00)			
	6	4	Boys	12.80 (4.90)	11.50 (3.70)	112.75 (23.70)			
	6	5	Girls	11.20 (2.20)	10.20 (2.20)	104.20 (10.90)			
	7 (M: 7.5 ± 0.2)	9		10.80 (2.10)	10.80 (2.90)	104.70 (14.80)			
	7	5	Boys	10.40 (2.60)	9.60 (3.40)	100.00 (17.00)			

	7	4	Girls	11.30 (1.50)	12.30 (1.30)		110.50 (7.90)			
	8 (M: 8.2 ± 0.2)	9		11.20 (1.70)	10.80 (2.70)		106.00 (11.80)			
	8	5	Boys	11.00 (1.90)	9.00 (2.00)		100.00 (11.40)			
	8	4	Girls	11.50 (1.70)	13.90 (1.60)		113.50 (7.90)			
	9 (M: 9.7 ± 0.3)	9		10.20 (2.50)	11.30 (2.10)		104.70 (10.00)			
	9	4	Boys	9.25 (3.50)	11.50 (2.40)		102.25 (14.80)			
	9	5	Girls	11.00 (1.40)	11.20 (2.20)		106.60 (4.90)			
Henrique et al.	3-5 (M: 4.83 ± 0.78)	206	TS	10.07 (1.95)	9.34 (2.25)					
	3-5 (M: 4.78 ± 0.85)	115	TS: Boys	10.16 (2.09)	9.43 (2.35)					
	3-5 (M: 4.88 ± 0.67)	91	TS: Girls	9.90 (1.76)	8.96 (2.06)					
	3-5 (M: 4.69 ± 0.83)	86	DS	10.49 (2.08)	9.75 (1.97)					
	3-5 (M: 4.78 ± 0.92)	42	DS: Boys	10.39 (2.17)	9.76 (1.88)					
	3-5 (M: 4.60 ± 0.74)	44	DS: Girls	10.58 (2.01)	10.53 (2.00)					
Johnstone et al.	Approx. 4-9 (M: 7.0 ± 1.1)	102	INT	7.50 (2.10)	6.90 (2.40)		83.20 (11.60)	24.60 (18.80)	21.50 (20.00)	18.90 (17.80)
	Approx. 4-9 (M: 7.4 ± 0.9)	21	CON	7.50 (1.60)	8.00 (2.70)		86.60 (11.20)	23.00 (13.70)	30.00 (25.90)	23.40 (19.80)
Khodaverdi et al.	8-9 (M: 8.78 ± 0.32)	352	Girls				76.26 (9.28)			
Kit et al.	3-5	330		10.00 (0.20)	8.50 (0.10)					
	3-5	167	Boys	9.50 (0.30)	8.60 (0.20)					
	3-5	163	Girls	10.50 (0.30)	8.50 (0.20)					
	3	100	3y	9.40 (0.40)	8.60 (0.20)					
	4	112	4y	10.50 (0.30)	8.40 (0.20)					
	5	118	5y	10.00 (0.30)	8.60 (0.30)					
Kordi et al.	4-6 (4.95 ± 0.83)	147				17.80 (6.30)	93.30 (18.90)			
	4-6	75	Boys	8.90	9.30	17.10 (5.80)	91.20 (17.30)			
	4-6	72	Girls	9.10	8.10	18.50 (6.80)	95.50 (20.30)			
Logan et al.	3-6	15	Boys					28.80 (22.50)	48.90 (23.30)	37.10 (23.30)
	3-6	17	Girls					37.10 (18.20)	37.30 (23.80)	34.40 (20.00)
	3-6 (M: 4.2 ± 0.7)	32						33.20 (20.40)	42.70 (23.90)	25.70 (21.30)
Logan et al.	5-8	32	Boys	5.70 (2.10)	8.70 (1.90)		82.90 (9.40)			
	5-8	33	Girls	5.90 (1.80)	8.80 (2.00)		84.00 (8.80)			
	M: 5.7 ± 0.38	30	KG	6.10 (1.40)	9.00 (1.90)		85.00 (6.90)			
	M: 6.7 ± 0.34	22	Grade 1	6.20 (1.90)	9.20 (1.70)		86.20 (8.60)			
	M: 7.8 ± 0.46	23	Grade 2	5.10 (2.30)	8.00 (2.20)		79.50 (10.10)			
	M: 6.7	65		5.80 (2.00)	8.70 (2.00)		83.50 (9.10)			17.20

Miklánková	M: 5.8 ± 0.38	62					111.24 (15.92)					
Mukherjee et al.	6-0 to 6-5 (M: 6.32 ± 0.07)	12	Boys	9.08 (2.54)	6.17 (2.08)	15.25 (3.41)	85.75 (10.24)	37.50 (23.70)	14.50 (14.80)	20.92 (20.69)	6-0	4-3
	6-6 to 6-11 (M: 6.70 ± 0.14)	38	Boys	8.45 (2.37)	5.79 (1.97)	14.24 (3.47)	82.71 (10.40)	32.89 (22.00)	12.03 (12.03)	16.84 (17.03)	6-0	4-6
	7-0 to 7-5 (M: 7.04 ± 0.05)	10	Boys	7.90 (1.66)	4.00 (1.83)	11.90 (2.23)	75.70 (6.70)	27.10 (15.16)	4.40 (5.17)	6.60 (4.86)	6-0	4-3
	8-0 to 8-11 (M: 8.79 ± 0.10)	21	Boys	7.19 (1.99)	5.14 (1.96)	12.33 (3.12)	77.00 (9.36)	21.67 (15.54)	8.76 (10.56)	9.48 (9.44)	6-6	5-9
	9-0 to 9-11 (M: 9.30 ± 0.21)	51	Boys	6.90 (2.39)	6.16 (1.25)	13.06 (2.72)	79.18 (8.15)	20.69 (19.47)	11.84 (7.64)	10.94 (10.39)	6-9	5-9
	6-0 to 6-5 (M: 6.34 ± 0.07)	13	Girls	8.31 (1.49)	5.08 (1.50)	13.38 (2.53)	80.15 (7.60)	30.69 (15.92)	7.00 (6.73)	11.69 (9.01)	5-6	3-9
	6-6 to 6-11 (M: 6.71 ± 0.15)	32	Girls	8.50 (2.11)	6.59 (1.97)	15.09 (3.24)	85.28 (9.71)	32.50 (20.82)	17.16 (15.47)	20.09 (17.34)	6-0	4-9
	7-0 to 7-5 (M: 7.04 ± 0.06)	15	Girls	7.80 (2.24)	4.87 (2.00)	12.67 (2.41)	78.00 (7.23)	27.73 (20.94)	7.87 (9.92)	9.07 (7.82)	6-0	4-6
	8-0 to 8-11 (M: 8.79 ± 0.09)	14	Girls	7.64 (2.37)	5.79 (1.89)	13.43 (3.23)	80.29 (9.68)	26.00 (23.69)	11.21 (7.20)	13.29 (14.26)	6-9	5-9
	9-0 to 9-11 (M: 9.29 ± 0.21)	38	Girls	7.34 (2.18)	5.58 (2.13)	12.92 (3.44)	78.76 (10.31)	23.76 (17.75)	11.16 (13.41)	11.76 (10.39)	7-0	6-3
Pang & Fong	6-0 to 6-5	15	Boys	13.70 (2.10)	10.50 (1.70)	24.30 (2.70)	112.60 (8.50)	84.60 (15.70)	57.70 (20.10)	77.00 (16.40)	10-0	6-9
	6-6 to 6-11	12	Boys	12.40 (2.00)	10.80 (1.80)	23.30 (2.90)	109.80 (8.60)	74.80 (17.10)	59.30 (21.00)	71.50 (17.10)	8-6	7-3
	7-0 to 7-5	15	Boys	12.50 (1.90)	11.00 (2.00)	23.50 (3.40)	110.40 (10.10)	75.90 (19.00)	61.70 (23.20)	72.60 (21.20)	>10-9	8-6
	7-6 to 7-11	13	Boys	12.00 (1.70)	11.20 (1.70)	23.20 (3.10)	109.70 (9.40)	72.50 (19.40)	64.00 (19.10)	71.50 (20.30)	>10-9	10-6
	8-0 to 8-11	28	Boys	11.70 (1.80)	10.50 (1.30)	22.20 (2.10)	106.50 (6.20)	69.40 (21.50)	56.40 (15.30)	65.80 (14.70)	>10-9	10-6
	9-0 to 9-11	8	Boys	11.30 (1.90)	9.60 (2.40)	20.90 (3.10)	102.60 (9.30)	64.40 (22.60)	46.60 (26.80)	56.80 (22.10)	>10-9	9-3
	6-0 to 6-5	9	Girls	14.00 (2.40)	11.70 (2.60)	25.70 (4.40)	117.30 (13.20)	85.20 (19.90)	66.60 (27.70)	80.90 (22.70)	10-0	7-6
	6-6 to 6-11	10	Girls	12.90 (1.80)	12.00 (2.60)	24.90 (3.90)	114.70 (11.60)	79.80 (16.10)	69.80 (26.50)	78.80 (22.50)	10-0	8-0
	7-0 to 7-5	21	Girls	11.70 (1.50)	11.50 (1.60)	23.20 (2.50)	109.60 (7.60)	69.60 (16.30)	67.30 (15.40)	71.80 (15.30)	10-0	8-3
	7-6 to 7-11	8	Girls	11.40 (1.50)	11.60 (2.20)	23.00 (2.90)	109.00 (8.60)	65.90 (17.20)	67.60 (24.60)	70.30 (18.60)	10-0	9-6
	8-0 to 8-11	28	Girls	11.60 (1.80)	12.00 (1.80)	23.60 (3.10)	110.90 (9.40)	68.50 (21.40)	72.60 (20.00)	73.80 (20.40)	>10-9	>10-9
Pienaar et al.	9.9 ± 0.63	826			9.23 (2.32)				41.65 (24.61)			8.89 (1.61)
	9.9 ± 0.46	433	Boys		8.79 (2.21)				37.53 (23.09)			8.72 (1.69)
	9.9 ± 0.46	393	Girls		9.73 (2.35)				46.33 (25.45)			9.08 (1.50)
Rechtik	5.9 ± 1.63	132					103.94 (21.92)					
Robinson et al.	3-5 (M: 4.61 ± 0.46)	14						28.70 (23.70)	30.70 (21.90)	26.80 (23.70)		
Spessato et al.	3-4 (M: 4.0 ± 0.5)	109	Boys								3.57 (1.00)	3.25 (0.91)
	5-6 (M: 6.1 ± 0.6)	175	Boys								4.68 (1.14)	4.54 (1.55)
	7-8 (M: 7.9 ± 0.6)	177	Boys								5.03 (1.43)	5.56 (1.51)
	9-10 (M: 9.9 ± 0.5)	180	Boys								5.59 (1.11)	6.29 (1.67)
	3-4 (M: 4.0 ± 0.5)	103	Girls								3.49 (0.96)	3.10 (0.76)
	5-6 (M: 6.1 ± 0.5)	173	Girls								4.50 (1.06)	3.88 (1.32)
	7-8 (M: 8.1 ± 0.6)	149	Girls								4.72 (1.22)	4.62 (1.16)

9-10 (M: 9.8 ± 0.5)	182	Girls		5.25 (1.08)	5.63 (1.25)

M: Mean, y: years

KG: Kindergarten

INT: Intervention group; CON: Control group; EXP: Experimental group

LM: Locomotor; OC: Object control; SS: Standard Score; GMQ: Gross Motor Quotient

DS: Dropout Sample; TS: Testing Sample

Table 5. Summary of the results of studies that reported distribution (i.e. proportion of children) across TGMD-2 performance categories

Authors	Age	N	Group	LM Categories							OC Categories							GMQ Categories						
				VP	P	BA	A	AA	S	VS	VP	P	BA	A	AA	S	VS	VP	P	BA	A	AA	S	VS
Aye et al.	5 (M: 5.41 ± 0.34)	472																0.6	2.5	6.1	46.2	20.1	17.6	6.8
Aye et al.	5 (M: 5.70 ± 0.31)	60																0	0	3.3	41.7	36.7	15	3.3
Balaban	8-11.99 (M: 9.22 ± 1.04)	201																			52	32	3	
Bardid et al.	3-8	1614		0.5	3.9	15.9	68.2	8.4	2.4	0.8	2	8.1	27.9	59.7	2	0.3	0	1.5	11.3	24.6	55.9	5.3	1.3	0
Kit et al.	3-5	330		1.3	7.6	15.8	54.8	13.3	4	3.3	2.2	7.3	24.9	61	3.2	1.4	0							
Kordi et al.	4-6 (M: 4.95 ± 0.83)	147																8.2	18.4	15	41.5	5.4	9.5	2
Miklánková	M: 5.8 ± 0.38	62																0	1.6	8.1	30.7	33.9	12.9	12.9
Mukherjee et al.	6-7.5	60	Boys	1.7	6.7	18.3	68.3	0	5	0	16.7	31.7	36.7	15	0	0	0	8.3	43.3	31.7	15	1.7	0	0
	6-7.5	60	Girls	0	5	26.7	65	1.7	1.7	0	13.3	36.7	28.3	21.7	0	0	0	8.3	33.3	38.3	18.3	1.7	0	0
	8-10	72	Boys	6.9	20.8	26.4	43.1	2.8	0	0	6.9	30.6	47.2	15.3	0	0	0	14	44.4	30.6	11.1	0	0	0
	8-10	52	Girls	5.8	13.5	26.9	51.9	1.9	0	0	15.4	19.2	53.8	11.5	0	0	0	15	34.6	36.5	13.5	0	0	0
Pang & Fong	6-0 to 6-5	15	Boys				33	27	40					80	20						20	47	33	
	6-6 to 6-11	12	Boys				58	25	17					83	17						58	25	17	
	7-0 to 7-5	15	Boys				53	33	13				7	73	20					7	33	47	13	
	7-6 to 7-11	13	Boys				54	46	0					69	31					8	46	31	15	
	8-0 to 8-11	28	Boys			4	39	57	0				4	93	4						68	32		
	9-0 to 9-11	8	Boys				63	38	0				25	63	13						13	63	25	
	6-9	91	Boys			1	37	41	11				4	80	15					3	52	35	10	
	6-0 to 6-5	9	Girls				22	22	56					56	33	11					22	33	44	
	6-6 to 6-11	10	Girls				40	40	20					60	20	20					30	30	40	
	7-0 to 7-5	21	Girls				76	24						86	9	5					67	29	5	
	7-6 to 7-11	8	Girls				63	38						63	38						50	38	13	
	8-0 to 8-11	28	Girls				46	54						57	43					4	32	46	18	
	6-9	76	Girls				53	38	9					66	29	5				1	42	37	20	
	6-0 to 6-5	24					29	25	46					71	25	4					29	42	29	
	6-6 to 6-11	22					50	32	18					73	18	9					46	27	27	
	7-0 to 7-5	36					67	28	6				3	81	14	3				3	53	36	8	
	7-6 to 7-11	21					57	43						67	33					5	48	33	14	
	8-0 to 8-11	56					43	55					2	75	23					2	50	39	9	
	9-0 to 9-11	8					63	38					25	63	13					11	56	25		

	6-9 (M: 7.6 ± 0.9)	167			1	50	39	10				2	74	22	2				2	47	36	14	
Pienaar et al.	M: 9.9 ± 0.63	826							0.2	4.8	17.9	69.1	6.8	1.2	0								
Rechtik	M: 5.9 ± 1.63	132														5.6	7.8	13.8	35.3	14.7	13.4	9.5	
Spessato et al.	4-7 (M: 5.36 ± 1.0)	178																2	44	28	14	12	
Tomaz et al.	3-6 (M: 5.2 ± 0.7)	259														0.8	1.2	5	60.2	23.6	7.7	1.5	
	3-6 (M: 5.2 ± 0.7)	130	Boys													0	1.5	3.1	65.4	23.9	5.4	0.8	
	3-6 (M: 5.2 ± 0.7)	129	Girls													1.6	0.8	7	55	23.3	10.1	2.3	

TGMD-2: Test of Gross Motor Development-2

LM: Locomotor; OC: Object Control; GMQ: Gross Motor Quotient

VP: Very Poor, P: Poor, BA: Below Average, A: Average, AA: Above Average, S: Superior, VS: Very Superior

Table 6 Summary of the results of studies that reported mastery levels based on the TGMD-2

	Age	n	Group	Mastery Levels (% achieving mastery)											
				Run	Gallop	Hop	Leap	Jump	Slide	Strike	Dribble	Catch	Kick	Throw	Roll
Bolger et al.	6 & 10	110	Boys	71.8	48.2	24.5	51.8	11.8	40.0	18.2	22.7	25.5	77.3	41.8	12.7
	6 & 10	93	Girls	87.1	58.1	32.3	65.6	12.9	48.4	21.5	28.0	18.3	40.9	18.3	1.1
	6	102	6y	80.4	43.1	19.6	54.9	10.8	38.2	18.6	0.0	5.9	39.2	16.7	1.0
	10	101	10y	77.2	62.4	36.6	61.4	13.9	49.5	20.8	50.5	38.6	82.2	45.5	13.9
Butterfield et al.	6-13 (M: 10.0 ± 2.4)	96	Boys							61.5		77.1	67.4	66.7	
	6-13 (M: 9.1 ± 2.5)	75	Girls							40.0		60.0	48.0	32.0	
dos Santos et al.	4	85											2.0		
	5	107											4.0		
	6	113											1.0		
	7	103											2.0		
	8	102											2.0		
	9	104											4.0		
	10	167											24.0		
Hardy et al.	4.0-4.9	159	Girls	69.0	36.0	29.0		23.0		6.0		18.0	22.0	9.0	
	4.0-4.9	171	Boys	76.0	28.0	21.0		21.0		20.0		22.0	44.0	23.0	
	4.0-4.9	330		73.0	31.0	25.0		22.0		14.0		20.0	35.0	16.0	
Mukherjee et al.	6-10	244		78.3	78.3	15.6	42.6	2.9	39.3	11.5	9.0	19.3	8.2	8.6	7.8
	6	95		77.9	72.6	16.8	40.0	2.1	27.4	4.2	1.1	6.3	5.3	4.2	5.3
	7	25		80.0	84.0	4.0	44.0	4.0	32.0	4.0	0.0	0.0	12.0	8.0	8.0
	8	35		74.3	77.1	17.1	37.1	8.6	48.6	14.3	20.0	31.4	14.3	5.7	8.6
	9	89		79.8	83.1	16.9	47.2	1.1	50.6	20.2	15.7	23.7	7.9	14.6	10.1
Wong & Cheung	3	115		1.7	0.0	0.0	6.1	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4	245		35.5	24.1	4.1	35.1	33.9	13.1	2.4	3.7	0.0	1.8	0.8	0.0
	5	270		70.7	31.9	0.0	41.5	43.7	23.0	7.4	5.2	1.5	42.2	2.2	1.5
	6	167		73.1	37.7	1.2	49.1	59.9	37.7	7.2	18.0	5.4	63.5	1.8	12.0
	7	127		84.3	77.2	7.1	48.8	74.8	59.1	33.9	38.6	12.6	33.9	3.1	3.9
	8	89		96.6	77.5	9.0	42.7	78.7	74.2	37.1	46.1	18.0	36.0	13.5	3.4
	9	108		88.9	74.1	12.0	72.2	80.6	67.6	38.9	47.2	10.2	59.3	7.4	14.8
	10	107		91.6	77.6	9.3	83.2	86.0	60.7	46.7	62.6	14.0	59.8	14.0	17.8

M: Mean; y: years

TGMD-2: Test of Gross Motor Development-2

Table 7. Weighted mean (± standard deviation) of the TGMD-2 scores for all age groups

	Age Group								Age Range			
	3y	**4y**	**5y**	**6y**	**7y**	**8y**	**9y**	**10y**	**3-5y**	**6-8y**	**9-10y**	**3-10y**
RAW SCORE												
LM	20.1 (1.7)	25.7 (3.9)	31.4 (5.8)	32.9 (5.2)	33.9 (5.2)	36.3 (5.8)	33.7 (4.3)	37.1 (5.1)	28.2 (6.0)	34.5 (5.4)	35.1 (4.8)	32.1 (6.1)
n	**700**	**1296**	**2627**	**2153**	**1527**	**2084**	**1239**	**828**	**5076**	**6087**	**2067**	**14195**
OC	15.6 (1.8)	19.3 (2.2)	25.0 (4.5)	28.8 (4.9)	30.0 (4.0)	34.0 (4.3)	32.3 (3.6)	35.2 (3.8)	22.0 (5.0)	31.2 (4.9)	33.5 (3.8)	27.9 (6.1)
n	**700**	**1296**	**2611**	**2130**	**1499**	**2060**	**1239**	**828**	**5133**	**6012**	**2067**	**14279**
Total	37.2 (4.0)	40.9 (4.1)	48.2 (5.8)	51.0 (5.3)	55.0 (3.8)	58.7 (3.2)	68.2 (0.0)	76.5 (4.0)	44.7 (6.1)	54.5 (5.2)	75.3 (4.9)	53.1 (7.6)
n	**157**	**447**	**771**	**422**	**242**	**308**	**23**	**129**	**1541**	**972**	**152**	**5574**
Run	4.7 (1.4)	6.3 (1.0)	6.4 (0.7)	6.4 (0.3)	6.8 (0.3)	7.1 (0.4)	7.1 (0.3)	7.4 (0.1)	6.2 (1.0)	6.7 (0.4)	7.2 (0.2)	6.4 (0.7)
n	**338**	**1078**	**1469**	**743**	**563**	**458**	**97**	**147**	**2885**	**1764**	**244**	**8420**
Gallop	3.4 (1.5)	4.0 (1.4)	5.1 (1.8)	4.5 (1.7)	5.2 (1.5)	5.1 (2.5)	7.5 (0.1)	7.5 (0.1)	4.5 (1.7)	4.9 (1.7)	7.5 (0.1)	5.0 (1.4)
n	**338**	**1078**	**1469**	**739**	**562**	**455**	**97**	**147**	**2885**	**1756**	**244**	**8412**
Hop	2.4 (0.2)	4.9 (1.1)	6.6 (1.9)	6.5 (1.6)	6.5 (1.9)	6.3 (1.8)	7.5 (0.2)	8.2 (0.3)	5.5 (2.1)	6.5 (1.7)	7.9 (0.4)	5.7 (1.5)
n	**338**	**1078**	**1469**	**743**	**563**	**458**	**97**	**147**	**2885**	**1764**	**244**	**8420**
Leap	3.1 (0.5)	3.8 (0.4)	4.0 (0.7)	4.4 (0.5)	4.0 (1.1)	4.3 (1.2)	2.7 (0.1)	2.9 (0.2)	3.8 (0.6)	4.3 (0.8)	2.8 (0.2)	4.0 (0.6)
n	**338**	**748**	**1469**	**743**	**563**	**458**	**97**	**147**	**2555**	**1764**	**244**	**8090**
Jump	3.5 (1.0)	4.0 (1.0)	4.4 (1.1)	4.4 (1.3)	5.1 (0.8)	5.1 (1.0)	6.0 (0.2)	5.8 (0.2)	4.1 (1.0)	4.8 (1.1)	5.9 (0.2)	4.2 (1.2)
n	**338**	**1078**	**1469**	**716**	**534**	**431**	**97**	**147**	**2885**	**1681**	**244**	**8337**
Slide	2.2 (1.0)	3.2 (1.9)	5.2 (2.2)	4.2 (2.7)	5.1 (2.9)	5.3 (3.0)	7.9 (0.1)	7.9 (0.0)	4.2 (2.2)	4.8 (2.6)	7.9 (0.0)	5.0 (1.9)
n	**338**	**748**	**1469**	**716**	**534**	**431**	**97**	**147**	**2555**	**1681**	**244**	**8007**
Strike	4.0 (0.7)	5.1 (1.4)	6.1 (1.2)	6.3 (0.9)	6.3 (0.9)	6.4 (0.8)	8.4 (0.8)	7.3 (1.3)	5.5 (1.4)	6.3 (0.9)	8.3 (1.0)	6.1 (1.2)
n	**338**	**1078**	**1469**	**1539**	**555**	**444**	**940**	**172**	**2885**	**2538**	**1112**	**10062**
Dribble	0.7 (0.3)	1.5 (0.3)	2.5 (0.9)	4.0 (0.4)	5.0 (0.8)	5.7 (1.1)	6.9 (0.1)	7.2 (0.2)	2.0 (0.9)	4.5 (0.9)	7.0 (0.2)	3.9 (1.6)
n	**338**	**748**	**1469**	**1549**	**563**	**458**	**923**	**147**	**2555**	**2570**	**1070**	**9722**
Catch	2.0 (0.2)	3.0 (0.8)	3.3 (0.3)	4.2 (0.7)	4.1 (0.5)	4.4 (0.4)	5.7 (0.3)	5.6 (0.2)	3.0 (0.7)	4.2 (0.6)	5.7 (0.2)	3.9 (1.0)
n	**338**	**1078**	**1469**	**1539**	**555**	**444**	**940**	**172**	**2885**	**2538**	**1112**	**10062**
Kick	4.3 (1.4)	5.2 (1.0)	5.9 (1.1)	5.9 (0.3)	5.5 (0.8)	5.8 (1.1)	7.1 (0.9)	5.8 (1.1)	5.5 (1.2)	5.8 (0.6)	6.9 (1.0)	5.4 (1.1)
n	**338**	**1078**	**1469**	**1566**	**584**	**471**	**940**	**172**	**2885**	**2621**	**1112**	**10145**
Throw	2.4 (0.4)	3.1 (0.5)	4.1 (1.2)	3.5 (0.7)	5.0 (0.5)	5.5 (0.6)	6.2 (0.7)	5.8 (1.0)	3.5 (1.1)	4.1 (1.1)	6.1 (0.7)	4.1 (1.2)
n	**338**	**1078**	**1469**	**1539**	**555**	**444**	**940**	**172**	**2885**	**2538**	**1112**	**10062**
Roll	2.9 (0.8)	3.4 (0.9)	4.1 (0.8)	4.4 (0.6)	4.9 (0.9)	5.0 (1.1)	6.2 (0.1)	6.5 (0.6)	3.8 (0.9)	4.6 (0.8)	6.2 (0.2)	4.3 (1.0)
n	**338**	**748**	**1469**	**1522**	**534**	**431**	**923**	**147**	**2555**	**2487**	**1070**	**9639**
STANDARD SCORE												
LM	9.4 (0.0)	10.4 (0.9)	11.5 (1.4)	9.7 (1.4)	9.4 (1.4)	8.9 (1.8)	6.5 (2.5)		10.5 (1.4)	9.3 (1.6)	6.5 (2.5)	9.9 (1.7)
n	**334**	**504**	**989**	**473**	**301**	**243**	**146**		**2408**	**1062**	**146**	**3729**

OC	8.8 (0.2)	8.6 (1.0)	9.4 (1.2)	8.0 (1.5)	8.1 (2.0)	7.9 (2.3)	6.5 (1.7)		9.1 (0.9)	8.0 (1.7)	8.8 (1.3)	8.7 (1.3)
n	**334**	**504**	**989**	**473**	**301**	**243**	**146**		**2465**	**1062**	**972**	**4612**
Total			23.0 (0.4)	17.8 (5.0)	19.9 (8.5)	19.0 (5.7)	13.7 (2.7)		21.9 (2.5)	18.7 (5.1)	13.7 (2.7)	20.2 (4.2)
n			**532**	**141**	**82**	**91**	**97**		**679**	**314**	**97**	**1090**
GMQ												
Score	94.9 (0.0)	97.4 (6.7)	104.2 (6.7)	94.1 (8.0)	92.5 (10.1)	90.5 (12.2)	83.0 (10.5)	89.5 (3.4)	100.1 (7.0)	88.7 (10.7)	86.2 (8.2)	94.3 (10.3)
n	**234**	**392**	**1065**	**575**	**301**	**243**	**106**	**101**	**1980**	**1516**	**207**	**3816**
PERCENTILE												
LM	55.3 (0.9)		71.0 (2.1)	48.7 (24.3)	35.0 (17.2)	51.4 (25.6)	25.5 (14.4)		60.0 (13.7)	40.4 (20.6)	25.5 (14.4)	49.6 (20.3)
n	**72**		**532**	**141**	**397**	**91**	**97**		**964**	**629**	**97**	**1871**
OC	44.6 (1.0)		51.9 (8.5)	29.4 (25.0)	27.5 (17.1)	43.4 (31.6)	14.4 (11.8)		47.5 (10.1)	30.2 (21.1)	38.8 (10.3)	39.9 (15.2)
n	**72**		**532**	**141**	**397**	**91**	**97**		**1021**	**629**	**923**	**2754**
Rank	55.8 (3.9)			37.0 (29.7)	52.3 (32.1)	47.2 (33.3)	30.4 (29.3)		44.5 (12.7)	43.9 (30.1)	30.4 (29.3)	36.2 (24.5)
n	**72**			**141**	**82**	**91**	**137**		**193**	**314**	**137**	**832**

TGMD-2: Test of Gross Motor Development-2

y: years

LM: Locomotor; OC: Object Control; GMQ: Gross Motor Quotient

Table 8. Weighted mean (± standard deviation) for subtest, total and individual skill scores based on the TGMD-2, stratified by sex and age groups

	3-5y		6-8y		9-10y		3-10y	
	Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
RAW SCORES								
LM	29.0 (5.6)	29.9 (5.5)	34.5 (4.8)	35.3 (5.4)	35.2 (5.1)	34.3 (4.7)	31.7 (6.0)	32.4 (6.2)
n	**2076**	**1926**	**2717**	**3145**	**1019**	**943**	**6658**	**6865**
OC	23.9 (5.3)	20.7 (5.4)	33.8 (3.8)	29.3 (5.0)	36.2 (1.9)	30.1 (2.6)	30.2 (6.1)	26.1 (5.9)
n	**2076**	**1926**	**2717**	**3070**	**1019**	**943**	**6715**	**6835**
Total	46.8 (1.3)	46.0 (0.2)	56.8 (0.0)	52.5 (0.0)			49.1 (8.7)	46.8 (6.0)
n	**226**	**200**	**244**	**241**			**1111**	**1156**
Run	6.1 (1.2)	5.9 (1.2)	6.7 (0.5)	6.6 (0.5)	7.3 (0.0)	7.2 (0.3)	6.3 (0.8)	6.4 (0.8)
n	**1083**	**967**	**805**	**722**	**114**	**146**	**2518**	**2432**
Gallop	5.0 (1.1)	5.7 (1.1)	5.1 (1.6)	5.3 (1.5)	7.5 (0.1)	7.5 (0.1)	4.6 (1.7)	4.9 (1.8)
n	**1083**	**967**	**722**	**797**	**114**	**146**	**2435**	**2507**
Hop	5.8 (2.2)	6.5 (2.0)	6.6 (1.7)	6.8 (1.8)	7.9 (0.2)	8.0 (0.7)	5.6 (2.0)	6.1 (1.9)
n	**1083**	**967**	**805**	**722**	**114**	**146**	**2518**	**2432**
Leap	3.7 (0.5)	3.5 (0.6)	4.0 (1.0)	4.3 (0.7)	2.9 (0.3)	2.8 (0.1)	3.9 (0.8)	3.9 (0.7)
n	**912**	**808**	**805**	**722**	**114**	**146**	**2347**	**2273**
Jump	4.7 (0.7)	4.7 (0.7)	5.0 (0.9)	5.1 (0.9)	5.8 (0.4)	5.9 (0.0)	4.5 (1.1)	4.4 (1.1)
n	**1083**	**967**	**722**	**722**	**114**	**146**	**2435**	**2432**
Slide	5.4 (1.5)	5.5 (1.7)	5.3 (2.4)	5.3 (2.5)	7.9 (0.1)	7.9 (0.0)	4.7 (2.4)	4.5 (2.5)
n	**912**	**808**	**722**	**722**	**114**	**146**	**2264**	**2273**
Strike	6.5 (1.1)	5.7 (1.0)	7.0 (0.7)	5.8 (0.9)	8.7 (0.7)	7.8 (1.2)	6.5 (1.5)	5.7 (1.5)
n	**1083**	**967**	**746**	**749**	**570**	**558**	**2915**	**2871**
Dribble	2.2 (1.1)	1.7 (1.1)	5.4 (1.1)	4.3 (1.0)	7.2 (0.2)	6.8 (0.2)	4.1 (2.2)	3.4 (2.1)
n	**912**	**808**	**805**	**722**	**547**	**539**	**2780**	**2666**
Catch	3.2 (0.7)	3.0 (0.8)	4.3 (0.5)	4.0 (0.5)	5.7 (0.2)	5.7 (0.3)	3.8 (1.1)	3.7 (1.2)
n	**1083**	**967**	**746**	**749**	**570**	**558**	**2915**	**2871**
Kick	5.7 (1.3)	4.9 (1.4)	6.0 (0.7)	5.2 (0.9)	7.3 (0.8)	6.5 (1.2)	6.1 (1.0)	5.4 (1.2)
n	**1083**	**967**	**829**	**749**	**570**	**558**	**2998**	**2871**
Throw	4.1 (1.2)	3.2 (1.2)	5.6 (0.4)	4.2 (0.6)	6.5 (0.3)	5.7 (0.8)	4.8 (1.3)	3.9 (1.3)
n	**1083**	**967**	**746**	**749**	**570**	**558**	**2915**	**2871**
Roll	4.4 (0.8)	4.1 (0.6)	5.3 (0.7)	4.6 (0.9)	6.4 (0.3)	6.0 (0.0)	4.8 (1.3)	4.2 (1.2)
n	**912**	**808**	**722**	**722**	**547**	**539**	**2697**	**2666**
STANDARD SCORES								
LM	10.5 (1.4)	10.9 (1.1)	9.5 (1.5)	9.4 (1.4)	7.6 (1.9)	7.8 (1.7)	9.8 (1.4)	10.1 (1.5)
n	**1185**	**1010**	**502**	**515**	**63**	**43**	**2659**	**1673**
OC	9.2 (0.8)	9.1 (1.1)	8.0 (1.7)	8.0 (2.0)	8.6 (1.0)	9.4 (1.5)	8.7 (0.8)	8.9 (1.4)
n	**1185**	**1010**	**502**	**515**	**496**	**436**	**3092**	**2066**
Total	22.9 (0.1)	23.0 (1.0)	18.4 (5.2)	19.0 (5.3)	14.1 (3.8)	12.9 (0.0)	19.9 (4.3)	20.5 (4.2)
n	**271**	**261**	**164**	**150**	**59**	**38**	**569**	**521**
GMQ								
Score	99.7 (7.1)	101.0 (7.1)	92.9 (9.1)	86.5 (11.3)	85.5 (7.9)	87.1 (10.0)	94.9 (7.3)	92.5 (11.4)
n	**861**	**712**	**554**	**917**	**121**	**86**	**2445**	**1820**
PERCENTILES								
LM	66.7 (8.8)	69.8 (6.8)	37.9 (23.7)	42.9 (17.8)	26.6 (21.2)	23.8 (0.0)	51.0 (23.8)	54.4 (19.9)
n	**343**	**300**	**316**	**313**	**59**	**38**	**723**	**697**
OC	49.7 (6.7)	51.6 (8.4)	28.4 (20.0)	32.1 (23.0)	35.0 (9.8)	43.2 (14.1)	38.2 (15.3)	42.8 (16.4)
n	**343**	**300**	**316**	**313**	**492**	**431**	**1156**	**1090**
Rank	52.9 (7.7)	53.3 (0.0)	42.9 (30.3)	45.1 (31.7)	17.2 (22.2)	11.8 (0.0)	38.9 (27.7)	40.5 (28.0)
n	**72**	**39**	**164**	**150**	**59**	**38**	**271**	**244**

TGMD-2: Test of Gross Motor Development-2

y: years

LM: Locomotor; OC: Object Control; GMQ: Gross Motor Quotient

Table 9. Weighted frequency of the proportion of children in each TGMD-2 performance category, for all age groups

	LM Categories							OC Categories							GMQ Categories						
	VP	**P**	**BA**	**A**	**AA**	**S**	**VS**	**VP**	**P**	**BA**	**A**	**AA**	**S**	**VS**	**VP**	**P**	**BA**	**A**	**AA**	**S**	**VS**
3-5y	1.3	7.6	15.8	54.8	13.3	4.0	3.3	2.2	7.3	24.9	61.0	3.2	1.4	0.0	2.2	4.7	7.9	46.4	20.0	13.4	5.4
n	**330**	**330**	**330**	**330**	**330**	**330**	**330**	**330**	**330**	**330**	**330**	**330**	**330**	**330**	**1132**	**1132**	**1132**	**1132**	**1132**	**1132**	**1132**
6-8y	0.4	2.4	10.0	57.0	23.0	7.2	0.0	6.3	14.3	14.8	50.7	12.8	1.2	0.0	3.5	16.0	15.8	34.3	21.7	8.1	0.0
n	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**	**287**
9-10y								0.2	4.8	17.9	69.1	6.8	1.2	0.0							
n								**826**	**826**	**826**	**826**	**826**	**826**	**826**							
3-10y	0.9	5.0	15.7	63.8	10.6	3.1	1.0	2.3	8.4	24.7	59.7	4.3	0.7	0.0	2.3	9.9	17.3	48.6	12.7	6.6	2.5
n	**2355**	**2355**	**2355**	**2355**	**2355**	**2355**	**2355**	**3181**	**3181**	**3181**	**3181**	**3181**	**3181**	**3181**	**3335**	**3335**	**3335**	**3335**	**3335**	**3335**	**3335**

TGMD-2: Test of Gross Motor Development-2

y: years

LM: Locomotor; OC: Object Control; GMQ: Gross Motor Quotient

VP: Very Poor, P: Poor, BA: Below Average, A: Average, AA: Above Average, S: Superior, VS: Very Superior

Table 10. Weight frequencies of mastery levels based on the TGMD-2 for all age groups

	Mastery Levels (% achieving mastery)											
	Run	**Gallop**	**Hop**	**Leap**	**Jump**	**Slide**	**Strike**	**Dribble**	**Catch**	**Kick**	**Throw**	**Roll**
3-5y	54.2	25.8	9.6	32.5	29.1	15.0	7.5	3.7	7.3	20.8	6.3	0.6
n	**960**	**960**	**960**	**630**	**960**	**630**	**960**	**630**	**960**	**1152**	**960**	**630**
6-8y	80.8	61.1	9.7	46.9	44.1	45.9	18.3	20.0	10.0	25.0	6.9	6.1
n	**640**	**640**	**640**	**640**	**640**	**640**	**640**	**640**	**640**	**958**	**640**	**640**
9-10y	84.7	74.1	18.5	66.9	47.9	57.5	32.3	45.2	21.3	38.8	20.2	14.3
n	**405**	**405**	**405**	**405**	**405**	**405**	**405**	**405**	**405**	**676**	**405**	**405**
3-10y	68.9	46.8	11.4	46.3	37.7	37.1	16.0	20.0	11.0	26.6	9.3	5.7
n	**2005**	**2005**	**2005**	**1675**	**2005**	**1675**	**2005**	**1675**	**2005**	**2786**	**2005**	**1782**

y: years

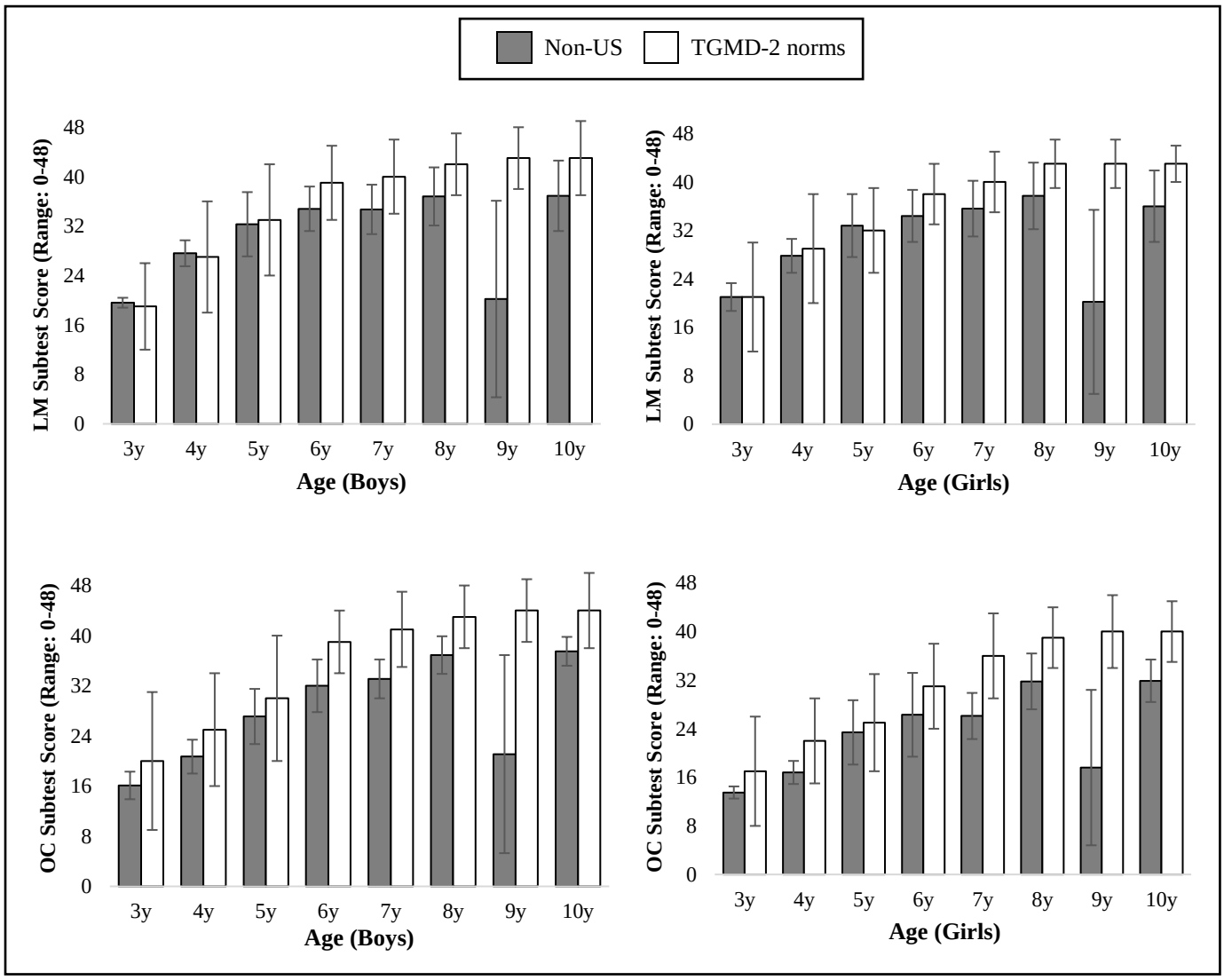

Non-US
TGMD-2 norms
LM Subtest Score (Range: 0-48)
0
8
16
24
32
40
48
3y
4y
5y
6y
7y
8y
9y
10y
Age (Boys)
Age (Girls)
OC Subtest Score (Range: 0-48)

Figure S1.

Table S1(a). Quality assessment checklist for cross-sectional studies

i	Was the research question or objective in this paper clearly stated?
ii	Was the study population clearly specified and defined?
iii	Was the participation rate of eligible persons at least 50%?
iv	Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study pre-specified and applied uniformly to all participants?
v	Was a sample size justification, power description, or variance and effect estimates provided?
vi	For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?
vii	Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?
viii	For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?
ix	Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?
x	Was the exposure(s) assessed more than once over time?
xi	Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?
xii	Were the outcome assessors blinded to the exposure status of participants?
xiii	Was loss to follow-up after baseline 20% or less?
xiv	Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?

Table S1(b). Quality assessment checklist for included cross-sectional studies

	i	ii	iii	iv	v	vi	vii	viii	ix	x	xi	xii	xiii	xiv	Quality of Study Rating
Antunes et al.	1	1	0	1	0	NA	NA	NA	NA	NA	1	NA	1	1	**High**
Aye et al.	1	1	NR	1	0	1	1	NA	1	0	1	NR	NA	0	**Medium**
Aye et al.	1	0*	NR	1	1	NA	NA	NA	NA	NA	1	NA	NA	NA	**High**
Bakhtiar	1	0*	NR	1	0	1	1	NA	1	0	1	NR	NA	0	**Medium**
Balaban	1	1	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Bardid et al.	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Barnett et al.	1	0	0	1	0	NA	NA	NA	NA	NA	1	NA	NA	1	**Medium**
Barnett et al.	1	1	0	1	0	NA	NA	NA	NA	NA	1	NA	NA	1	**High**
Bolger et al.	1	1	1	1	1	NA	NA	NA	NA	NA	1	NA	NA	1	**High**
Butterfield et al.	1	0	NR	1	1	NA	NA	NA	NA	NA	1	NA	NA	1	**High**
Cano-Cappellacci et al.	1	1	0	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Cepicka	1	0*	NR	1	1	NA	NA	NA	NA	NA	1	NA	NA	0	**High**
Chan et al.	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Chow & Chan	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Clark et al.	1	0*	NR	1	1	NA	NA	NA	NA	NA	1	NA	NA	0	**High**
Cliff et al.	1	1	0	1	0	NA	NA	NA	NA	NA	1	NA	NA	1	**High**
Crane et al.	1	1	0	1	0	NA	NA	NA	NA	NA	1	NA	1	1	**High**
da Silva et al.	1	1	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	1	**High**
De Meester et al.	1	0*	NR	0	0	NA	NA	NA	NA	NA	1	NA	NA	1	**Medium**
dos Santos et al.	1	0	NR	0	1	1	1	NA	1	NA	NR	NA	NA	0	**Medium**
Du Plessis et al.	1	1	1	1	1	NA	NA	NA	NA	NA	1	NA	NA	0	**High**
Field & Temple	1	1	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Freitas et al.	1	1	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	1	**High**
Grant-Beuttler et al.	1	0	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	1	**Medium**
Hall et al.	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	1	**Medium**
Hardy et al.	1	1	1	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**High**
Henrique et al.	1	1	NR	1	0	NA	NA	NA	NA	NA	1	NA	1	1	**High**
Khodaverdi et al.	1	0*	0	1	0	NA	NA	NA	NA	NA	1	NA	NA	1	**Medium**
Kim et al.	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Kit et al.	1	1	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Korbecki et al.	1	1	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
LeGear et al.	1	0*	1	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**High**
Lin & Yang	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Liong et al.	1	0*	0	1	0	NA	NA	NA	NA	NA	1	NA	NA	1	**High**
Logan et al.	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Logan et al.	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Miklánková	1	1	1	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**High**
Mukherjee et al.	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Palmer & Brian	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Pang & Fong	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Pienaar et al.	1	1	NR	1	0	NA	NA	NA	NA	NA	1	NA	0	1	**Medium**
Rechtik	1	1	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Robinson et al.	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	1	**High**
Rudd et al.	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Slykerman et al.	1	1	0	1	0	NA	NA	NA	NA	NA	1	NA	NA	1	**High**
Spessato et al.	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	1	**High**
Spessato et al.	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Tomaz et al.	1	1	NR	1	0	1	1	1	0	0	1	NR	NA	1	**Medium**

Valentini	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Wong & Cheung	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Wong & Cheung	1	0*	NR	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**
Yang et al.	1	0*	1	1	1	NA	NA	NA	NA	NA	1	NA	NA	0	**High**
Zuvela et al.	1	0*	0	1	0	NA	NA	NA	NA	NA	1	NA	NA	0	**Medium**

*denotes study population was clearly defined and specified but the time period at which assessment was conducted were not reported

Table S2. Quality assessment checklist for pre-post study designs

	Capio et al.	Kordi et al.	Robinson et al.
Was the study question or objective clearly stated?	1	1	1
Were eligibility/selection criteria for the study population pre-specified and clearly described?	1	1	1
Were the participants in the study representative of those who would be eligible for the test/service/intervention in the general or clinical population of interest?	1	1	1
Were all eligible participants that met the pre-specified entry criteria enrolled?	1	NR	NR
Was the sample size sufficiently large to provide confidence in the findings?	NR	NR	0
Was the test/service/intervention clearly described and delivered consistently across the study population?	1	1	1
Were the outcome measures pre-specified, clearly defined, valid, reliable, and assessed consistently across all study participants?	1	1	1
Were the people assessing the outcomes blinded to the participants' exposures/interventions?	0	NR	NR
Was the loss to follow-up after baseline 20% or less? Were those lost to follow-up accounted for in the analysis?	1	NR	NR
Did the statistical methods examine changes in outcome measures from before to after the intervention? Were statistical tests done that provided p values for the pre-to-post changes?	1	1	1
Were outcome measures of interest taken multiple times before the intervention and multiple times after the intervention (i.e., did they use an interrupted time-series design)?	0	0	0
If the intervention was conducted at a group level (e.g., a whole hospital, a community, etc.) did the statistical analysis take into account the use of individual-level data to determine effects at the group level?	1	1	1
Quality of Study Rating	**High**	**Medium**	**Medium**

Table S3. Quality assessment checklist for intervention studies

	Adamo et al.	Bakhtiari et al.	Brian et al.	Cenizo- Benjumea et al.	Invernissi et al.	Johnstone et al.	Miller et al.	Rudd et al.
Was the study described as randomized, a randomized trial, a randomized clinical trial, or an RCT?	1	0	0	0	0	0	1	0
Was the method of randomization adequate (i.e., use of randomly generated assignment)?	1	NA	NA	NA	NR	NA	1	0
Was the treatment allocation concealed (so that assignments could not be predicted)?	1	NA	NA	NA	NR	NA	1	0
Were study participants and providers blinded to treatment group assignment?	NR	NR	0	NA	NR	NR	NR	NR
Were the people assessing the outcomes blinded to the participants' group assignments?	0	NR	0	NR	NR	NR	1	1
Were the groups similar at baseline on important characteristics that could affect outcomes (e.g., demographics, risk factors, co-morbid conditions)?	1	1	NR	1	1	1	1*	1
Was the overall drop-out rate from the study at endpoint 20% or lower of the number allocated to treatment?	1	1	1	NR	NR	1	1	1
Was the differential drop-out rate (between treatment groups) at endpoint 15 percentage points or lower?	1	1	1	NR	NR	1	1	1
Was there high adherence to the intervention protocols for each treatment group?	NR	NR	1	NR	NR	NR	1	1
Were other interventions avoided or similar in the groups (e.g., similar background treatments)?	NR	NR	NR	NR	NR	1	NR	NR
Were outcomes assessed using valid and reliable measures, implemented consistently across all study participants?	1	1	1	1	1	1	1	1
Did the authors report that the sample size was sufficiently large to be able to detect a difference in the main outcome between groups with at least 80% power?	0	0	0	0	0	0	1	0
Were outcomes reported or subgroups analysed pre-specified (i.e., identified before analyses were conducted)?	1	1	1	1	1	1	1	1
Were all randomized participants analysed in the group to which they were originally assigned, i.e., did they use an intention-to-treat analysis?	1	1	1	NR	NR	1	1	1
Quality of Study Rating	**Medium**	**Medium**	**Medium**	**Low**	**Low**	**Medium**	**High**	**Medium**

*denotes similar age, socio-economic status, and OC proficiency but differences between catch proficiency and in-class PA levels