Universidade de Lisboa

Faculdade de Motricidade Humana

RELATIONSHIP BETWEEN ESTIMATION AND REAL MOTOR PERFORMANCE IN SCHOOL-AGE CHILDREN

Dissertação elaborada com vista à obtenção do Grau de Doutor em Motricidade Humana, Especialidade de Reabilitação

Orientador: Professor Doutor Rui Fernando Roque Martins

Co-Orientadora: Professora Doutora Rita Cordovil Matos

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Gabriela Sousa Neves de Almeida

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To my parents, brother and husband for believing in me.

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Abstract

The relationship between estimated and real motor competences was analyzed for several tasks. Participants were 303 children (160 boys and 143 girls), which had between 6 and 10 years of age (*M*=8.63, *SD*=1.16). None of the children presented developmental difficulties or learning disabilities, and all attended age-appropriate classes. Children were divided into three groups according to their age: group 1 (N= 102; age range: 6.48-8.01 years); group 2 (N= 101; age range: 8.02-9.22 years); and group 3 (N=100; age range: 9.24-10.93 years).

Children were asked to predict their maximum distance for a locomotor, a manipulative, and a balance task, prior to performing those tasks. Children's estimations were compared with their real performance to determine their accuracy.

Children had, in general, a tendency to overestimate their performance (standing long jump: 56.11%, kicking: 63.37%, throwing: 73.60%, and Walking Backwards (WB) on a balance beam: 45.21%), and older children tended to be more accurate, except for the manipulative tasks.

Furthermore, the relationship between estimation and real performance in children with different levels of motor coordination (Köperkoordinationstest für Kinder, KTK) was analyzed. The 75 children with the highest score comprised the Highest Motor Coordination (HMC) group, and the 78 children with the lowest score were placed in the Lowest Motor Coordination (LMC) group. There was a tendency for LMC and HMC children to overestimate their skills at all tasks, except for the HMC group at the WB task. Children with the HMC level tended to be more accurate when predicting their motor performance; however, differences in absolute percent error were only significant for the throwing and WB tasks.

In conclusion, children display a tendency to overestimate their performance independently of their motor coordination level and task. This fact may be determinant to the development of their motor competences, since they are more likely to engage and persist in motor tasks, but it might also increase the occurrence of unintended injuries.

Keywords

Children, estimation, motor competence, fundamental movement skills, motor coordination

Relação entre estimativa e performance motora real em crianças em idade escolar

Resumo

O objetivo principal deste estudo foi analisar a relação entre a estimativa e a competência motora real, para várias tarefas envolvendo habilidade motoras fundamentais, em 303 crianças (160 rapazes e 143 raparigas) com idades compreendidas entre os 6 e os 10 anos (*M*=8.43, *DP*=1.16). As crianças frequentavam o 1.º ciclo e não apresentavam alterações no desenvolvimento e na aprendizagem. As crianças foram divididas em três grupos de acordo com a sua idade: grupo 1 (N= 102; 6.48-8.01 anos); grupo 2 (N= 101; 8.02-9.22 anos) e grupo 3 (N=100; 9.24-10.93 anos).

Foi solicitado às crianças para estimarem a distância máxima que julgavam conseguir antes de executar uma tarefa: locomotora (saltar em comprimento), manipulativa (lançar e chutar uma bola para uma baliza) e estabilizadora (caminhar à retaguarda numa trave de equilíbrio com 6 cm de largura, 3 cm de altura e 3 m de comprimento). As suas estimativas foram comparadas com o seu desempenho motor real para determinar a precisão nas tarefas.

As crianças deste estudo mostraram uma tendência para sobrestimar as suas habilidades motoras (saltar: 56.11%, chutar: 63.37%, lançar: 73.60%, caminhar à retaguarda numa trave: 45.21%) e as crianças mais velhas foram mais precisas nas suas estimativas, com exceção das tarefas manipulativas.

Adicionalmente, este estudo pretendeu explorar se as estimativas das crianças, para as mesmas tarefas motoras, estavam relacionadas com o seu nível de coordenação motora. Com base no teste de coordenação motora *Köperkoordinationstest für Kinder*, as 75 crianças com a pontuação mais alta (quartil superior) e as 78 crianças com a pontuação mais baixa (quartil inferior) foram selecionadas para este objetivo; formaram, respectivamente, o grupo das crianças com alta coordenação motora (ACM) e o grupo das crianças com baixa coordenação motora (BCM). As crianças sobrestimaram as suas competências, exceto o grupo com ACM na tarefa de caminhar à retaguarda, e o grupo das crianças com BCM apresentou um erro percentual absoluto superior para todas as tarefas, mas apenas significativo para o lançamento e caminhar na trave.

Em conclusão, as crianças tendem a sobreestimar as suas reais competências motoras independentemente da tarefa e do seu nível de coordenação. Esta constatação pode ser determinante no que respeita ao desenvolvimento das competências motoras, uma vez que as crianças serão mais propensas a se envolver e persistir em tarefas motoras, no entanto, e por outro lado, poderá levar a criança a colocar-se em situações de risco e originar a ocorrência de lesões não intencionais.

Palavras-chave

Crianças, estimativa, competência motora, habilidades motoras fundamentais, coordenação motora

List of Publications

PAPERS IN INTERNATIONAL JOURNALS

Luz, C., Rodrigues, L. P., **Almeida**, G., & Cordovil, R. *(2015).* Development and validation of a model of motor competence in children and adolescents. Journal of Science and Medicine in Sport 01/2016; DOI:10.1016/j.jsams.2015.07.005

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Luz, C., **Almeida**, G., Rodrigues, L. P., & Cordovil, R. (2014). The influence of weight status on physical fitness of primary school children. *Rev Saúde Pública*; 48(n.esp):190-281.

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Table of Contents

List of Figures

List of Tables

Abbreviations

AE	-	**A**bsolute **E**rror
AA	-	**A**ctual **A**bility
ADHD	-	**A**ttention **D**eficit/**H**yperactivity **D**isorder
APE	-	**A**bsolute **P**ercent **E**rror
ASDs	-	**A**utism **S**pectrum **D**isorder**s**
DCD	-	**D**evelopmental **C**oordination **D**isorder
EA	-	**E**stimated **A**bility
FMS	-	**F**undamental **M**ovement **S**kills
HMC	-	**H**ighest **M**otor **C**oordination
HR	-	**H**orizontal **R**each
ID	-	**I**ntellectual **D**isability
KTK	-	**K**öperkoordinations**t**est für **K**inder
LMC	-	**L**owest **M**otor **C**oordination
LVF	-	**L**eft **V**isual **F**ields
MH	-	**M**aximum **H**eight
MRH	-	**M**aximum **R**eaching **H**eight
MVPA	-	**M**oderate- to **V**igorous-**I**ntensity **P**hysical **A**ctivity
OC	-	**O**bject **C**ontrol
PA	-	**P**hysical **A**ctivity
PMC	-	**P**erceived **M**otor **C**ompetence
RVF	-	**R**ight **V**isual **F**ields
SLJ	-	**S**tanding **L**ong **J**ump
TD	-	**T**ypically **D**eveloping
TGMD-2	-	**T**est of **G**ross **M**otor **D**evelopment
WB	-	**W**alking **B**ackwards
yrs	-	**Y**ea**rs**

CHAPTER 1

INTRODUCTION

Introduction

Children's perceived competence in the physical domain has attracted considerable interest in both motor skill development and sport psychology literatures. Perceived physical competence represents a psychological judgment about children's perception of how able they are in the physical domain (Harter, 1999). A positive judgment of their self-ability in motor competence seems to be determinant to the development of their motor skill competences. Children with high perception of competence are more likely to engage, persist, and master in motor tasks (Harter, 1978, 1999).

The construct of perceived competence emerges from the model of competence motivation that underlies the construction of the perceived competence, across different domains (Harter, 1978; 1982). Concepts such self-worth, self-concept, and self-esteem are central in the study of child's perception in the physical, social and cognitive domains (Harter, 1978, 1999). According to Harter (1982), the perceived physical competence domain, in elementary school children, focuses on sports and outdoors games. This domain has been assessed in different areas of study, such as psychology (*e.g.*, Coplan, Findlay, & Nelson, 2004; Nelson et al., 2009), sport psychology (*e.g.*, Bois, Sarrazin, Brustad, Trouilloud, & Cury, 2005; Brustad, 1993), and motor development (*e.g.,* Hurmeric, 2010; Savage, 2002).

Several scales *(e.g.,* Fox, & Corbin, 1989; Harter, 1982; Harter, & Pike, 1984; Marsh, 1996; Pérez, & Sanz, 2005; Whitehead, 1995) based on self-reported measures have been developed to use with children and adolescents, providing a profile of the child's perceived physical competence or physical self-concept, based on how good they think they are in sports. The scales assess the perception of physical or motor competence, having different items according to the skill differences across the chronological ages. The scales discriminate between children with low and high-perceived competence.

The level of perceived physical competence is known to be dependent on developmental differences and gender. According to Harter (1982), children with ages up to approximately 8 years are often inaccurate, being unrealistically positive about their abilities and they often confound the wish to be competent with reality. Children perceive themselves as highly competent but, in fact, they often have low motor competence. The tendency of young children to overestimate their abilities is developmentally normal and might serve to motivate them towards greater levels of persistence, attempts and mastery (Harter, 1982; 1999). Higher perceived competence is related with motor skill proficiency and increased levels of physical activity (Stodden et al., 2008). The overestimation of children's capabilities may have a positive effect on engaging them in motor activities and sports that improve motor proficiency. The accuracy of children's perception improves with age and cognitive development (Harter, 1982; 1999). Children become increasingly more capable of making realistic judgments about their competence during elementary school years (Harter, 1982).

It should be noted, however, that, as mention above, within the Harter's theory, the measure of perceived physical competence is not obtained directly by doing the physical task. The relationship between children's perception and real motor skill competence, obtained by a direct measure of performance, in order to ascertain whether the perceptual estimation reflects accuracy of the limits of their action capabilities, is a different line of research, based on Gibson's ecological approach (Gibson, 1977, 1979) to perception and action. This approach has provided the theoretical framework to the studies on the perception of judgments in actions capabilities. A central concept of Gibson's theory of direct perception is *affordance*, defined as the intrinsic relationship between a person's action capabilities and the properties of the environment. Crucial to the concept of *affordance* is the body-scaled *affordances*' notion that indicates that body size is the limiting factor in determining what actions are possible (Fajen, Riley, & Turvey 2009). This line of research has focused in the participants' estimations of their action capabilities or *affordances* for familiar actions, that is, whether or not an action is possible. Furthermore, the terms accuracy, and over- and underestimation bias are used, rather than high or low perception.

Gabbard, Caçola and Cordova (2009) conducted a study with 7-9- and 11 year-olds children to examine the relationship between the estimation of reachability and the perceived motor competence. The authors hypothesized that children with high-perceived motor competence would exhibit greater overestimation and that younger children would display greater overestimation bias. They had used Harter's scale to measure their perceived motor competence, while their estimation and actual maximum reach was assessed by an experimental paradigm. The results confirmed the overestimation bias for each age group, with the 7 years old group scoring significantly higher on the perceived motor competence. These findings indicated that the overestimation bias was not significantly associated with the level of general perceived motor competence. Furthermore, the authors suggested that the perceived motor competence, as a general measure based on a psychological construct, may "*not reflect the intentions or real motor abilities*" (Gabbard, Caçola, & Cordova, 2009, pg.156), and suggest more studies "*tied to context-specific measures of perceived abilities in relation to the specificity of the task*" (pg.157). However, literature studies assessing children's real and perceived motor competence using the same skills, as tasks of real skill ability, are scarce. As for research based on Harter's theory, the studies that analyzed the estimation of action capabilities with a match task, tend to empirically support that, in general, children are less accurate than adults, exhibiting the tendency to overestimate the limits of their ability (*e.g.,* Caçola, & Gabbard, 2012; Plumert, 1995; Rochat, 1995). The level of accuracy in the perception of a person's action capabilities seems to improve along lifespan *(e.g.,* Klevberg, & Anderson, 2002).

Children use their motor repertoires to engage in various physical activities, sport and games across their lifespan (Gallahue, & Ozmun, 2006). This repertoire is developed as a result of the combination of many factors such as experience, motor competences, and environmental or individual constraints. In this motor repertoire, Fundamental Movement Skills (FMS) are the main skills that children with ages 2-7 years are expected to improve, to achieve a proficient level. These are gradually combined in a variety of ways to become sport skills (Gallahue, & Ozmun, 2006). FMS should persist for most part of the lifespan and are commonly categorized as fundamental locomotor skills (*e.g*., running, leaping, jumping, and hooping), fundamental manipulative skills (*e.g*., throwing, catching, and kicking), and fundamental stability skills (*e.g*., dynamic, and static balance). Locomotor and manipulative movement skills engage an element of dynamic balance (Gallahue, & Cleland-Donnelly, 2007). The mastery of FMS is essential for the acquisition of more advanced, specific, and refined movement activities. In addition, a greater perceived motor competence in FMS has been related with the future adoption of active and healthier lifestyles (Stodden et al., 2008).

Following the suggestion of evaluating perceived motor competence using context-specific measures, instead of a general measure based on a psychological construct (Gabbard, Caçola, & Cordova, 2009), the purpose of this research was to directly examine the estimation of FMS in children and to compare it with their real performance.

Within the scope of an ecological perspective to perception and action, and based on the findings in the field of childhood, demonstrating children's tendency to systematic overestimate their physical abilities (*e.g.,* Schwebel, & Bounds, 2003), five empirical questions have guided the present investigation: (1) How accurate are children in estimating their movement skills? (2) Are younger and older children equally accurate in their estimations? (3) Is there a gender difference in the accuracy of estimations? (4) Does the accuracy in estimations differ for different FMS (locomotor, manipulative, and dynamic balance tasks)? (5) Is estimated motor competence in children adjusted to their level of motor coordination?

We had specific initial hypotheses. Firstly, we hypothesized that, in general, children overestimate their real performance. More specifically, we expected younger children to be less accurate than older children, and children with a higher level of motor coordination to be more accurate than children with a lower level of coordination. Secondly, we expected that estimation in a non-common action (walking backwards on a balance beam) would be more conservative than in locomotor and manipulative estimations, which are highly practiced actions in childhood (see Cole, Chan, Vereijken, & Adolph, 2013).

This thesis comprises four studies that compared estimations of school-age children with their real performance. The experimental tasks required 6- to 10 year-olds children to estimate their maximum performance for four FMS: jumping, throwing, kicking, and walking backwards. We intended to determine whether the estimations of these children reflected an accurate knowledge of their real performance.

In Study 1 children estimated their maximum standing long jump, which is a locomotor task. Study 2 evaluated children's estimation for two manipulative skills: throwing and kicking. Study 3 was designed to assess children's accuracy in the estimation of a balance task: walking backwards on a balance beam. All studies in this research used the same protocol: an estimation-first condition prior to the performance of the estimated task. The estimation task had no feedback from the evaluator. The results of the 3 studies are presented in Chapter 3 of this thesis.

A forth study, presented in Chapter 4, examined the relationship between estimated motor competence and real motor performance in children with different motor coordination levels. More specifically, we aimed at determining whether children with the lowest motor coordination level were less accurate than children with highest motor coordination level, when estimating their maximum performance.

Prior to presenting the experimental studies, we provide a systematic review of the literature concerning the relationship between estimation and real performance of motor skills in children (Chapter 2). These studies have been conducted using different theoretical approaches and have not been critically reviewed or synthesized before. Our purpose was to determine how accurate children are in estimating their performance in different tasks, and also if age (*i.e.*, different age groups) and task conditions (*i.e.*, different motor skills), influence the estimation accuracy.

The final section of this thesis (Chapter 5) presents a general conclusion, research limitations and suggestions for future direction in this field.

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CHAPTER 2

Relationship Between Estimation And Real Motor Performance In School-age Children: A Systematic Review

Gabriela Almeida, Carlos Luz, Rui Martins, Rita Cordovil

Relationship Between Estimation And Real Motor Performance In School-age Children: A Systematic Review

Abstract

The perception that children have of their action capabilities guides the way they act in the world. The purpose of this study was to systematically review the literature on the estimation of motor competence in children. We were specifically interested in knowing how accurate children are when estimating their competence in different motor skills and if age (*i.e.*, between different age groups and when compared to adults' accuracy) influenced estimation accuracy. In addition, we intended to identify which variables have been used to assess estimation error. A systematic search in five databases (Science Direct, PubMed, Web of Science, Academic Search, and Scopus) was conducted to identify and summarize the relevant studies reporting on examining the relationship between estimation and real performance of motor skills, in children. The search was restricted to articles written in English and published between the 1st of January 1995 and the 30th of June 2014. Systematic search of electronic databases and reference lists identified 20 peer-reviewed studies, which met the inclusion *criteria* and provided results associated with the research questions. We found evidences that young children have a greater tendency to overestimate their abilities in different tasks and adults are more accurate in estimating their real performance than children.

Keywords

Fundamental movement skills, children, systematic review, motor performance, overestimation

2.1. Introduction

The perception that children have of their motor competence changes across development and has been studied as a psychological construct (Harter, 1978; 1999) assessed by questionnaires (*e.g.*, Harter, 1982; Harter, & Pike, 1984; Pérez, & Sanz, 2005). Studies that address Perceived Motor Competence (PMC) as a psychological construct have shown that during early childhood, children tend to not distinguish accurately between competence, ability and effort, which generally lead them to have an inflated perception of their motor competence (Stodden et al., 2008; Harter, & Pike, 1984). This inflated perception seems to be particularly beneficial for children's early motor development, driving them to persist and engage in mastery attempts in activities which they believe they are skillful (Harter, & Pike, 1984; Harter, 1999; Klint, & Weiss, 1987; Robinson, 2011; Stodden et al., 2008). By middle childhood, children are able to more accurately compare themselves to their peers and their self-evaluation of motor competence becomes more realistic (Harter, & Pike, 1984; Harter, 1999). This developmental shift seems to have important consequences in the adoption or not of future active lifestyles (Stodden et al., 2008).

Motor skills include posture, locomotion (*e.g*., running, jumping, hopping), ballistic skills (*e.g*., catching, throwing, kicking), and manipulative skills (*e.g*., grasping, reaching) (Haywood, Roberton, & Getchell, 2012). As motor skills develop over time, the choice of motor activities by children is linked to their real motor skill competence and Physical Activity (PA) levels, and apparently also to their perception of competence, success, persistence, and intrinsic motivation to participate and engage in PA (Fisher et al., 2005; Stodden et al., 2008). Stodden and colleagues (2008) proposed a developmental model that hypothesizes that there are reciprocal relationships between PA, health related fitness and perceived and real motor skill competence. The model suggests that PMC is a mediating variable for the engagement in PA and sports, that is, children that perceive themselves as having less motor skill competence are less likely of engaging in physical activity and more likely to become inactive than children who perceive themselves as having high skill competence (Stodden et al., 2008).

Although PMC is an important psychological construct, it might not have a direct relation with children's ability to estimate their motor competence in task-specific activities. Gabbard, Caçola and Cordova (2009) examined the influence of the level of PMC in the estimation ability of 7-, 9-, and 11-year-old children in a reaching task, concluding that the overestimation bias that most children exhibited was not related to their general measure of PMC. Furthermore, the authors concluded that PMC is not a good predictor of children's action planning in the specific task of reach estimation and "*suggest research [to] be tied to context-specific measures of perceived abilities in relation to the specificity of the task*" (Gabbard, Caçola, & Cordova, 2009, pg.157).

The perception that children have of their action capabilities in specific tasks guides the way they act when performing those tasks and might have important consequences for their effort and persistence. However, the misperception of action capabilities might also be a problem in terms of child safety (Cordovil, Araújo, Pepping, & Barreiros, 2015). For example, if a child estimates that he/she can jump over an impossible wide gap, the attempt of jumping might lead to injury. Different studies, framed in the area of the perception of *affordances* (Gibson, 1979), have tried to understand how people (mostly adults) perceive their action limits when confronted with a particular set of environmental conditions (*e.g.,* Carello, Grosofsky, Reichel, Solomon, & Turvey, 1989; Mark, & Vogele, 1987; Warren, 1984; Warren, & Wang, 1987). The perception of one's action limits is related to both the actor's dimensions (body-scaled *affordances*), and behavioral capabilities (action-scaled *affordances*) (Fajen, Riley, & Turvey, 2009). During childhood, both dimensions and capabilities continuously change but not always at a constant rate, being expectable that the perception of one's limits of action in different tasks suffers a necessary adjustment. However, studies that analyze the adjustment of children's perception in different motor tasks seem to be scarcer than studies with adults.

To our knowledge, no published systematic reviews have summarized studies concerning the relation between estimated motor competence (via estimation of motor ability) and real motor performance in children obtained by a direct measure (*i.e*., using motor competence tasks that match the actual skill assessed). A systematic review of the literature is useful to synthesize the available data on estimation of motor performance in different motor skills and to understand the developmental changes that occur in the accuracy of estimations. The purpose of this study was to systematically review the literature relative to the following questions: (1) Which movement skill tasks have been used to assess estimation?; (2) How are estimations evaluated? (*i.e.,* dichotomous yes or no questions *vs*. quantitative measurements); (3) Does estimation accuracy improve with age?; (4) Which variables are used to measure the estimation error?

Therefore, the main goals of this systematic literature review were to examine how accurate children are when estimating their motor skill competence in different motor skills, and if children are different from adults in the accuracy of their estimations.

2.2. Methods

2.2.1. Sources and Search Strategy

A systematic literature search was performed using the following databases: Science Direct, PubMed, Web of Science, Academic Search, and Scopus. The search strategy combined four groups of terms regarding: (i) action, (ii) estimation, (iii) motor skills, and (iv) group of interest. The first group of terms aimed to capture the actor's relationship with the environment (*i.e.,* action limit or action capabilities or *affordance*). The second group of terms included terminology that captured variations to the term estimation (*i.e*, perception or perceiving or perceived or estimation or judgment). The third group of terms focused on the outcomes of interest (*i.e.*, motor skill or motor competence or fundamental motor skills or physical abilities)[1]. The last group of terms focused on the population of interest (child or children and adults). Individualized search strategies for the different databases included combination of the keywords.

2.2.2. Study Selection – *criteria* for inclusion/exclusion

Articles dating from the 1st January 1995 to the 30th of June 2014 were considered for inclusion. Only studies published in peer-reviewed journals and written in English were included. Articles identified through the above mentioned keywords were reviewed relative to predetermined inclusion and exclusion *criteria*, defined below.

In the first stage of the research, articles were excluded or included by screening their titles for relevance. When the appropriateness of the article could not be determined solely by the title, the abstract was also screened. When the relevance of the article could not be determined by the abstract the full article was examined. Detailed discussions were conducted between some of the authors (GA[2], CL[3], and RC[4]) concerning accepting or rejecting studies. All discrepancies were noted and discussed until agreement between the authors was reached.

In the second stage of the work, full text articles were retrieved and considered for inclusion. When opinion differed, concerning the eligibility of a study for inclusion according to the *criteria*, a consensus was reached through discussion. In addition to the electronic search, and in order to ensure that the search was exhaustive, a manual search was completed and an expert in the field was contacted to provide additional relevant articles. Therefore, in the final stage, additional articles were assessed for possible inclusion.

The following inclusion *criteria* were defined before the systematic literature search was performed. An article was considered for inclusion if it met the following inclusion *criteria*: (i) assessment of a motor skill; (ii) participants were children (studies that compared children's and adults' estimations were also included); (iii) an estimated skill

[1]The phrase "and" was used between groups and the phrase "or" was used within groups
[2] Gabriela Almeida
[3] Carlos Luz
[4] Rita Cordovil

measure and a real performance measure were assessed using the matching skills as tasks of real skill ability; (iv) participants first estimated their maximum ability and performed the matched task after that; (v) estimations were compared with the performance to determine the accuracy of the self-evaluations; (vi) estimated measure was directly asked to the participant; (vii) studies occurred in real life environments.

Our search strategy intended to include all studies that analyzed the accuracy of children when estimating their competence in different motor skills. Therefore, studies targeting children or adolescents with Neurodevelopmental Disorders, according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5, 2013) classification (*e.g.*, Autism Spectrum disorder, Motor Disorders), were included.

In addition, articles were excluded when they assessed the estimation of motor competence through a psychological construct based on a self-reported measure; when the estimated competence did not match the actual skill assessed; when there were no child participants; when there was no prediction task before the action task; and when they occurred in a virtual reality environment. Publications that did not include data analysis on the error measure were also excluded (comparison of estimation and actual ability). Unpublished work, conference proceedings, psychometric studies, abstracts, review papers, meta-analysis studies were not included. Articles were excluded when they were published in a language other than English or published before 1995. Figure 1 depicts the flow diagram of the search for relevant articles.

2.2.3. Data Extraction

The following data were extracted from each article using a standardized form: references (author, year), participants, assessed skill, procedure (estimation of skill tasks), error measure variables and findings. Two authors (GA and CL) scanned all references identified through the search strategy for initial selection and three authors (GA, RM[5] and RC) verified inclusion and cheeked for accuracy.

2.3. Results

The initial search on electronic databases identified a total of 458 potentially relevant articles. After screening the titles and abstracts and removing duplicates, 79 of potential studies were identified that met the relevance *criteria*. Seventy articles were excluded

[5] Rui Martins

because the described studies did not meet the inclusion *criteria*. After checking the reference list of each of these papers and getting feedback from an expert in the field, a total of 11 articles were added in the review. Finally, twenty articles met the inclusion *criteria*, and their characteristics are summarized in Tables 1-3. All twenty studies included in this systematic review have an estimation task before the real task (measures from performance), to compare participants' estimation with their real ability to perform the task. Seven studies (35%) targeted typically developing children (see Table 1), and four (20%) children with neurodevelopmental disorders (see Table 2). Nine studies (45%) were conducted with children and adults (see Table 3). All twenty studies provided results associated with questions 1, 2 and 4. Nine yielded studies also pertaining to question 3, that is, investigated estimation and real performance with respect to developmental differences.

2.4. Summary of Study Characteristics and Discussion

The purpose of this study was to systematically review and summarize the literature in the relationship between estimation and real motor performance in children. Two main findings emerged from this systematic review. The first was that children tend to overestimate their motor competence. Secondly, children tend to be less accurate than adults.

2.4.1. Studies in Typically Developing Children

Seven studies reported the research examining the relationship between estimation and real motor performance in children. Publication years ranged from 1997 to 2014. The sample size of the studies varied from 41 (Gabbard, Caçola, & Cordova, 2008) to 103 toddlers (Schwebel, & Plumert, 1999). The majority of the studies were in primary/elementary schools (4 to 11 years) with only one study considering toddlers (M=32.86 months) (Schwebel, & Plumert, 1999). The horizontal reach was the most common measure, used in six studies. Other assessed skills were stepping, vertical reach, and clearance. Three studies (Gabbard et al., 2008) only assessed one skill (horizontal reach), whereas the other three assessed four skills (Plumert, & Schwebel, 1997; Schwebel, & Plumert, 1999; Schwebel, & Bounds, 2003).

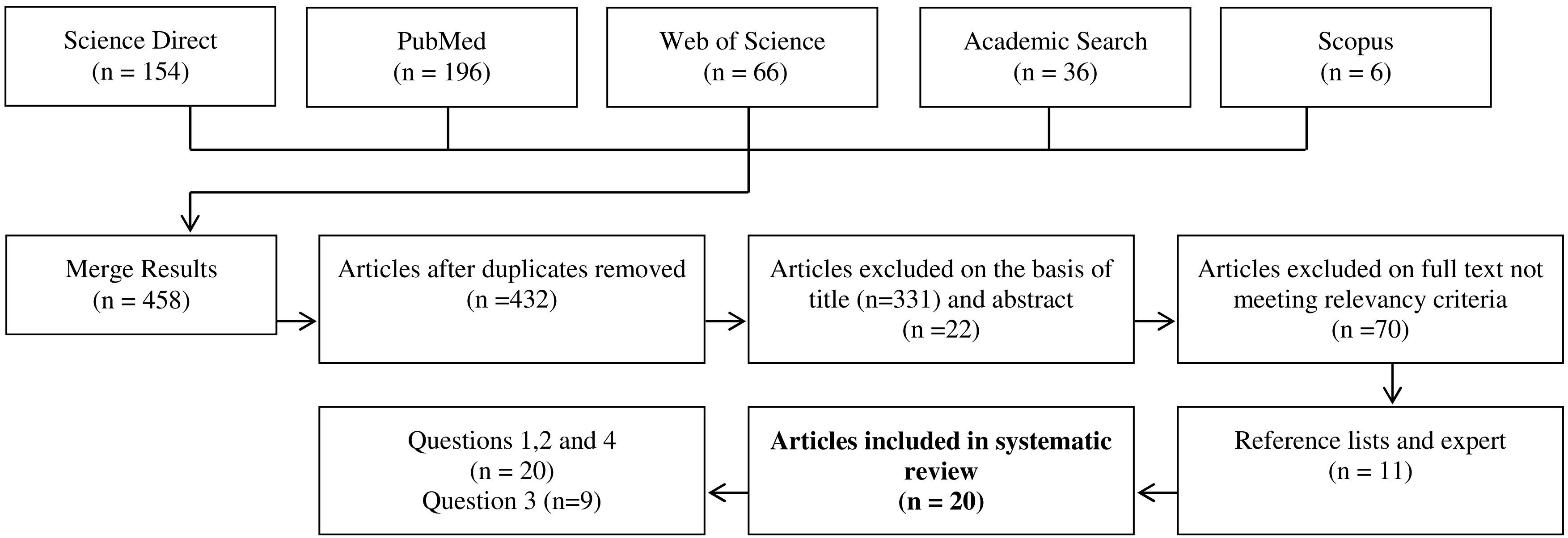

Figure 1 - Flow diagram of the search for relevant articles

Table 1 - Studies on estimation and real performance in children

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
(Barnett, Ridgers, & Salmon, 2014)	102 children aged 4-8 yrs (*M*= 6.3 yrs, *SD*= .92)	Investigate associations between children's perceived and actual OC competence and physical activity	6 **OC skills** in the TGMD-2 (striking a stationary ball, stationary dribble, kicking, catching, overhand throwing, and underhand rolling)	Pictorial instrument to assess perceived OC competence based on the OC skills in the TGMD-2 4 possible options for item (really good, pretty good, sort of good, not that good)	**Score range** 6-24 (a higher score reflected higher perceived competence)	Girls had lower perceived and actual OC skills and levels of MVPA than boys; Actual OC competence was associated with perceived OC
(Gabbard, Caçola, & Cordova, 2008)	10 seven year-olds (*M*= 6.73 yrs, *SD*= .4) 16 nine year-olds (*M*= 8.47 yrs, *SD*= .5) 15 eleven year-olds (*M*= 10.92 yrs, *SD*= 1.1)	Examine the relationship between estimated reachability and general motor imagery ability	**Horizontal reach**	Participants judged whether a stimulus was reachable (yes/no)	**Total error (%)** **Distribution and direction of error**	Most error occurred around distal targets, indicating an overestimating; All groups showed a slight tendency to overestimate
(Gabbard, Caçola, & Cordova, 2009)	13 six year-olds (*M*= 6.7 yrs, *SD*= .4) 15 nine year-olds (*M*= 8.5 yrs, *SD*= .5)	Examine the relationship between perceived motor competence and estimated reachability	**Horizontal reach**	Participants judged whether the stimulus was reachable (yes/no)	**Total error (%)** **Error tendency**	All age groups overestimated; No age differences in total error; Each group displayed more error in extrapersonal space

Table 1 - Studies on estimation and real performance in children

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
	13 eleven year-olds (*M*= 10.9 yrs, *SD*= 1.1)					
(Gabbard, Cordova, & Lee, 2009)	12 seven year-olds (*M*= 6.7 yrs) 16 nine year-olds (*M*= 8.5 yrs) 15 eleven year-olds (*M*= 10.9 yrs)	Examine the effects of perceived postural constraint (seated *vs* one foot standing) on estimated reachability	**Horizontal reach**	Participants judged whether the projected image was in (yes) or out of reach (no)	**Total error (%)** **Distribution and direction of error**	No differences in age groups or postural condition; Children have the tendency to overestimate
(Plumert, & Schwebel, 1997)	32 six year-olds (*M*= 6 yrs 5 m, range = 6 yrs to 7 yrs 1 m) 32 eight year-olds (*M* = 8 yrs 7 m, range = 8 yrs 1 m to 9 yrs)	Examine social and temperamental influences on children's judgments of their PA, and relations between temperamental characteristics, ability overestimation, and accidental injuries	**Vertical reach** **Horizontal reach** **Stepping** **Clearance**	(i) Children observed a peer succeed or fail; (ii) predicted their ability, and (iii) performed the tasks; Children decided whether or not they could perform each one of the four tasks (yes/no)	**Error tendency**	Children (6 and 8 years) who first watched the peer fail made more conservative judgments about their own abilities than did children who watched the peer succeed; More active and undercontrolled children (6 years) made less accurate judgments; Children (8 years) had more accurate judgments than 6yrs, and all children

Table 1 - Studies on estimation and real performance in children

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
						had more accurate judgments just within their ability than just beyond; Children (8 years) had more accurate judgments just beyond than 6 years; Ability overestimation was related to accident severity for 6yrs males; temperamental characteristics were related to accident severity for 8 years
(Schwebel & Plumert, 1999)	Toddlers-age (N=103, *M*=32.86 months; *SD* = 4.09) Preschool-age (N=99, *M*=46.01 months; *SD* = 2.62) School-age (N=59, *M*=75.85	Examine longitudinal and concurrent relations between temperament, ability estimation and injury proneness	**Vertical reach** **Horizontal reach** **Stepping** **Clearance**	Children decided whether or not they could perform each one of the four tasks (yes/no)	**Error tendency**	Children who were high on extraversion and low on inhibitory control as toddlers and pre-schoolers, tended to overestimate PA and have more unintentional injuries at 76 months; Toddlers and preschoolers low on extraversion and high on inhibitory control tended to underestimate PA at 76 months

Table 1 - Studies on estimation and real performance in children

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
	months; *SD* = 4.47)					
(Schwebel & Bounds, 2003)	33 six year-olds (*M*=79.86 months; *SD* = 4.71); 31 eight year-olds (*M*=103.16 months; *SD* = 5.34) *parents**	Examine children's estimation of PA, parent's estimation of children's PA, the role of parental presence in children's estimation of PA, and the role of parental proximity in *parents' estimation of children's PA**	**Vertical reach** **Horizontal reach** **Stepping** **Clearance**	Children were instructed to think carefully about whether or not they could complete the tasks successfully (yes/no) Parents made estimations about children's ability to perform de tasks: if the child will say he/she can complete the tasks; if they think he/she can complete the task	**Error tendency**	Children and parents overestimate children's PA, but children do so to a greater amount than parents; Temperamentally impulsive and undercontrolled children were more accurate when parents were standing next; Parents of temperamentally impulsive and undercontrolled children judged that children could complete tasks that were actually beyond the child's ability

MVPA - moderate- to vigorous-intensity physical activity; m – months; OC – object control; PA - physical ability(ies); TGMD-2 – Test of gross motor development; yrs – years; * *affordances for the other*

Only one study used a self-reported pictorial instrument to measure the perceived Object Control (OC) competence (Barnett, Ridgers, & Salmon, 2014), with six assessed real OC tasks (striking a stationary ball, stationary dribble, kicking, catching, overhand throwing and underhand rolling). In this study, children were required to choose which picture they related to, between 'good' and 'poor' skill performance. Although a self-report instrument based on "how good they think they are" does not meet our inclusion *criteria*, it was included because the perceived competence matched the real skills assessed. The other six studies measured the estimation of motor competence with a *yes* or *no* response. These studies looked into differences between age groups. For the error measure, four different error measures were used: error tendency (over- or underestimation), total error (%; based on a total score, *i.e.,* overall accuracy across targets), distribution and direction of error, and score range (higher score reflected higher perceived competence).

Although the studies found on estimation of motor competence had samples with distinctive ages, they all pointed in the same direction: children have a tendency to overestimate their motor competence, that is, they judge that they can perform motor tasks that are actually beyond their real ability. One study had, additionally, analyzed parents' estimation of children's abilities (*affordances* for the other), and how a child's estimation if affected by the presence of one of their parents (Schwebel, & Bounds, 2003). Findings revealed that parents overestimate children's ability, although to a lesser extent than children, and children estimated more cautiously their abilities when parents are present.

2.4.2. Studies on Neurodevelopmental Disorders

Developmental Coordination Disorder (DCD), Attention-Deficit/Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD) are comprised, in the fifth revision of the DSM-5 (2013), in the category of neurodevelopmental disorders, which begin during the developmental period. A total of four studies, published between 2007 and 2013, provide evidence on the relationship between estimation and real performance of motor skills in children and adolescents with neurodevelopmental disorders: DCD (Johnson, & Wade, 2007, 2009), ADHD (Helseth, Bruce, & Waschbusch, 2013), and ASD (Linkenauger, Lerner, Ramenzoni, & Proffitt, 2012). These studies used as comparison groups, Typically Developing (TD) children. Children were enrolled in the primary/elementary and middle schools. One study (Linkenauger et al., 2012) extended to adult age. Two studies included only boys (Helseth et al., 2013; Linkenauger et al., 2012). The sample sizes for the studies ranged from 8 (Linkenauger et al., 2012) to 22 participants (Johnson, & Wade, 2007).

Table 2 - Studies on estimation and real performance in children, adolescents and adults with neurodevelopmental disorders

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
(Helseth, Bruce, & Waschbusch, 2013)	39 boys aged 10-12 yrs (M = 11.15, *SD* = .81): 24 children with ADHD and 15 without ADHD	Compare the self-evaluations of physical abilities in children with and without ADHD	**Vertical reach** **Horizontal reach** **Stepping** **Clearance**	Children judge whether they could successfully perform the tasks (yes/no)	**Error tendency**	Children with ADHD overestimate their physical ability as the tasks became more difficult
(Johnson & Wade, 2007)	22 children at risk for DCD (M = 10.6 yrs, *SD* = 1.09) 22 TD children (M = 10.6 yrs, *SD* = 1.09)	Evaluate the ability to accurately perceive the limits of action capabilities (the tendency to over- or underestimate and the overall accuracy)	**Vertical reach** **Sitting height**	Participants judged the maximum height at which they could reach a ball with the tip of the extended hand's index finger Participants viewed a seat that was slowly raised or lowered, and judged the greatest height at which the seat afforded sitting (stop command)	**Constant error** **Absolute error**	AE, on both tasks, was greater in the DCD group; Both groups underestimated the judgment of maximum sitting height; There was a greater tendency in the DCD group to overestimate on descending trials and underestimate on ascending trials
	24 children between 10-11 yrs (*M*=10.5, *SD*=.51) and 19 children at risk	Analyze the correlation between a perceptual judgment task and a related movement task (WB)	**Horizontal reach**	Participants stood upright and judged how far they could reach by bending the waist and extending the arm and fingers toward	**Absolute error**	There was a correlation between the movement task (WB) and the related perceptual task (HR) for TD children; DCD and TD groups

Table 2 - Studies on estimation and real performance in children, adolescents and adults with neurodevelopmental disorders

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
	for DCD (*M*=10.79 yrs, *SD*=.58) 14 TD children (*M*=10.47 yrs, *SD*=.51)	and, an additional movement task (shifting pegs) and judgment task	**Vertical reach**	the target Participants judged the maximum height at which they could reach a ball with the tip of the extended hand's index finger		differed in the accuracy of the perceptual judgment tasks on both judgment tasks
(Johnson & Wade, 2009)	12 children at risk for DCD (*M*= 11 yrs 6m, *SD* = 6.8) 12 TD children (*M*= 11 yrs 3m, *SD* = 6.8)	Examine the relationship between perception and movement in children with DCD; Investigate whether the children's judgments favored either the normal (one-hand reach, standard effective foot-length, and rigid support surface) or the altered conditions (two-hand reach, short effective foot-length, and compliant support	**Horizontal reach**	Participants stood upright and judged the maximum distance they could reach by bending at the waist (stop command);	**Mean judge HR**	For the foot-length and support surface manipulations, children correctly judged that their actual HR differed in the two conditions; TDC group made greater adjustments, and adjusted their judgments in the appropriate direction for all manipulations, while DCD group did so only for the foot-length manipulation; DCD group made smaller (or incorrect) adjustments in response to each of the 3 manipulations

Table 2 - Studies on estimation and real performance in children, adolescents and adults with neurodevelopmental disorders

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings	
		surface); Examine how conditions changed the performance on each of the 3 manipulations: (1) one-hand *vs* two-hand reach; (2) standard *vs* short effective foot-length; and (3) rigid *vs* compliant support surface					
(Linkenauger, Lerner, Ramenzoni, & Proffitt, 2012)	12 male adolescents (9–13 yrs, *M*= 11.08) with high-functioning ASDs 12 age- matched TD male adolescents (9–13 yrs, *M*= 11.08) 8 male adults (18–34 yrs, *M* = 22.38) with high-functioning ASDs 8 TD male adults (17–21 yrs, *M*= 18.75)	Examine adolescents' accuracy in their ability to perceive *affordances* Examine if the difficulty in determining *affordances* extends into adulthood	**Horizontal reach** **Horizontal grasp** ***Aperture passability (hand)***	Participants informed the experimenter when they thought the chip was just at the limit of their reach Participants were told to anticipate whether they could grasp the block (yes/no response) Experimenter slowly decreased the size of the hole until participants indicated that they	**% error**	The amount of error between groups differed, with adolescents with ASDs making larger error; Adults with ASDs made larger error than TD	On average, ASD' s estimations deviated from their actual capabilities by 28%, in comparison with 8% from TD participants;

Table 2 - Studies on estimation and real performance in children, adolescents and adults with neurodevelopmental disorders

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
				could just fit their dominant hand through the hole		adults

AA - Actual Ability; ADHD - Attention Deficit/Hyperactivity Disorder; AE - Absolute error; ASDs - Autism Spectrum Disorders; DCD - Developmental Coordination Disorder; EA - Estimated Ability; HR - Horizontal Reach; m – months; TD - Typically Developing; WB - walking heel-to-toe backwards along a line; yrs - years

In terms of assessed skills, the Horizontal Reach (HR) was the most assessed ability followed by the vertical reach. The other assessed abilities were: stepping, clearance, sitting height, horizontal grasp, and aperture hand passability. Two of the studies made two experiments, and only one study assessed one skill (Johnson, & Wade, 2009). Different error variables were used for the analysis between estimation and actual ability: i) Mean judged HR scaled to actual HR (>1: judged HR greater than actual HR; <1: judged HR less than actual HR); ii) percentage error, obtained by taking the absolute value of the ratio of estimated ability over actual ability subtracted from 1 and multiplying by 100; iii) error tendency (overestimation, underestimation); iv) Constant error (judgment-actual); v) and absolute error (|judgment-actual|). A dichotomous question format (yes/no) or verbal stop commands were used to determine the estimation of maximum motor competence.

In terms of findings, all studies reported that children with neurodevelopmental disorders were more likely to make less accurate estimations than their TD peers. Johnson and Wade (2007) found that children at risk for DCD were less accurate when judging their action capabilities; however this difference was for the magnitude of error and not in the bias towards over- or underestimation. Moreover, children at risk for DCD are less competent at detecting when their action capabilities are altered (Johnson, & Wade, 2009). One study found that adolescents with ASDs had difficulty determining their *affordances* and this difficulty extends into adulthood (Linkenauger et al., 2012). Helseth and colleagues (2013) found that children with ADHD were more likely to overestimate their skills than children without ADHD, particularly when the tasks were more difficult.

2.4.3. Studies comparing children with adults

Nine studies, published between 1995 and 2012, examined the relationship between estimation and real performance comparing children and adults. The sample size of the studies varied from 13 (Klevberg, & Anderson, 2002) to 71 children (Gabbard, Cordova, & Ammar, 2007), and 12 (Klevberg, & Anderson, 2002) to 29 adults (Gabbard et al., 2007). The ages of the participants ranged from 3 years to 12 years for the children, and 19 to 26 years for the adults. One study included 13 older adults (*M*=60.8 years) (Cesari, Formenti, & Olivato, 2003). The horizontal reach was the most commonly assessed ability (Caçola, & Gabbard, 2012; Cordova, & Gabbard, 2011a; Cordova, & Gabbard, 2011b; Gabbard et al., 2007; Gabbard, & Cordova, 2012; Plumert, 1995; Rochat, 1995). Abilities such as stepping, clearance, vertical reach, upright stance and stair climbing were also assessed. The majority of the studies targeted one assessed skill, but Rochat (1995) assessed two skills (horizontal and vertical reach) and one study (Plumert, 1995) assessed four motor abilities (horizontal and vertical reach, stepping and clearance). The effect of age was evaluated not only between adults and children, but most studies also comprised different age groups for children and adults to examine the accuracy of judgments in different stages of development. Six studies reported one experiment and two reported two experiments (Caçola, & Gabbard, 2012; Plumert, 1995). The second experiment of Plumert's (1995) study was conducted only with elementary school-aged children.

Verbal estimation (yes or no) was the most commonly used procedure to determine the judgments of skills. Cordova and Gabbard (2011a) required an oral response of distance estimation in reference to the actual maximum reach. In the study of Klevberg and Anderson (2002), participants were asked whether they tought they could stand on a slope straight up, and both a yes or no response and a response to a confidence scale varying from "very, very confident" to "not at all confident", were registed. One study used a stair climbing task (Cesari et al., 2003), in which the participants should identify the stairs with the greatest riser height that they thought they could climb without suport. In the Rochat's study (1995), the participants were asked (yes/no question) to judge whether an apple was in their own or others (the experimenter) reach (*affordances* for the self and for other).

These studies used various error measures: total score (overall accuracy, % of correct responses), distribution of error across targets (differences between right and wrong answers), mean error, absolute error, absolute judgment, relative accuracy (estimate/actual x 100), constant error, distribution (%) and general distance of the error, estimation error, total error (%), mean error by space (%), overall accuracy (the number of correct responses out of the total number of trials), mean error (that is, direction of the error: under- or overestimation), error tendency (under- or overestimation), perceptual response (yes/no) and confidence judgments.

In term of outcomes, overall, adults were more accurate than children, and younger children were less accurate than older children. The results of Rochat's study (1995) show that 3 years old children are already able to distinguish between what is reachable for them and what is reachable for others.

Table 3 - Studies on estimation and real performance in children and adults

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
(Caçola & Gabbard, 2012)	11 six-seven year-olds (*M*=6.86 yrs) 12 eight-nine year-olds (*M*=8.35 yrs) 17 ten-twelve year-olds (*M*=11.10 yrs) 17 adults (19-23yrs; *M*=21.53)	Examine age-related ability to modulate peripersonal and extrapersonal space via arm and tool use (20 cm)	**Horizontal reach**	Verbal estimation of judgments of reachability (yes/no)	**Total score** **Distribution of error across targets**	Children and adults were less accurate in extrapersonal space, indicating an overestimation bias; Compared to adults, children displayed more error (overestimation bias) at all targets with significant distinctions at extrapersonal space
	14 six-seven year-olds (*M*=7.29 yrs) 11 eight-nine year-olds (*M*=8.91 yrs) 11 ten-twelve year-olds (*M*=10.55 yrs) 19 adults (19-23yrs; *M*=20.58)	Examine age-related characteristics associated with tool (40 cm) use in the perception and modulation of peripersonal and extrapersonal space				Children (7 and 9 years) were less accurate compared to adults; Participants tended to be more accurate in extrapersonal space and tended to underestimate
(Cesari, Formenti, & Olivato, 2003)	13 older adults (*M*=60.8 yrs, *SD*=6.4)	Examine whether a common perceptual parameter is available for guiding old adults,	**Stair climbing**	The stairs were arranged in a semicircle in a decreasing order of the height step and the participants were asked to	**Mean error**	The large majority of the participants underestimated their ability to climb a stair;

Table 3 - Studies on estimation and real performance in children and adults

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
	13 young adults (*M*=21.2 yrs, *SD*=2) 13 children (*M*= 6.7yrs, *SD*=1.7)	young adults and children in climbing the highest possible stair in a bipedal fashion		identify the one with the greatest riser height they thought they could climb without outside support or using their hands;		Old adults presented more precision in selecting the stairs compared to children and young adults
(Cordova & Gabbard, 2011a)	17 five year-olds (*M*=5.61 yrs) 14 seven year-olds (*M*=7.72 yrs) 18 nine year-olds (*M*=9.47 yrs) 17 eleven year-olds (*M*=11.36 yrs) 17 adults (*M*=21.53yrs)	Examine the age-related ability to estimate object location independent of the self	**Horizontal reach**	Participants estimated how far a cued target was from a response target, in immediate and response-delay conditions (oral response of distance estimation; 7 targets/range -3 to3)	**Absolut error** **Constant error**	Adults were more accurate than children; 5 and 7 year-olds displayed more difficulty with delays ≥2'', than the other groups
(Cordova & Gabbard, 2011b)	17 five year-old (*M*=5.7 yrs) 14 seven year-olds (*M*=7.9 yrs) 18 nine year-olds (*M*=9.6 yrs)	Examine children's ability to code visual information into an egocentric frame of reference for planning reach movements	**Horizontal reach**	Participants were instructed to respond immediately in reference to whether the stimulus (no delay, 1", 2" and 4" delay) was ''reachable''or not (yes/no)	**Distribution (%) and general distance of the error** **Estimation error**	1" delay was sufficient for decrements to be seen for 5 years and 7 years compared with older groups; Children's overestimation increased with the delay, more than adults;

Table 3 - Studies on estimation and real performance in children and adults

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
	17 eleven year-olds (*M*=11.4 yrs) 17 adults (*M*=21.6yrs)					5 years children had more error in extrapersonal space when compared with the other age groups; In adults, there were differences between no-delay and 4" delay conditions
(Gabbard, Cordova, & Ammar, 2007)	25 six year-olds (*M*=6.5yrs) 24 eight year-olds (*M*=8.6yrs) 22 ten year-olds (*M*=10.7 yrs) 29 adults (*M*=21.0 yrs)	Examine the ability to estimate reachability for objects placed in peripersonal and extrapersonal space	**Horizontal reach**	Participants judged whether a target was within reach (yes/no)	**Total error (%)** **Mean error by space (%)**	Children displayed a greater tendency to overestimate, especially in extrapersonal space; All children groups exhibited more errors in extrapersonal space; Adults were more accurate with extrapersonal targets
(Gabbard & Cordova, 2012)	15 five year-olds (*M*=5.91 yrs, *SD*=.33) 14 seven year-olds (*M*=7.32 yrs, *SD*=.71) 14 nine year-olds (*M*=9.03 yrs,	Examine the effects of target information, presented in different visual fields (lower, upper, central), on estimates of reach in children compared with adults	**Horizontal reach**	Participants judged whether the target was reachable (yes/no)	**Overall accuracy** **Distribution of error across targets** **Mean error**	Children were less accurate than adults; All age groups overestimated in the lower field, whereas the 11 years and adults underestimated in the upper field

Table 3 - Studies on estimation and real performance in children and adults

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
	SD=.02) 16 eleven year-olds (*M*=11.18 yrs, *SD*=.33) 17 adults (*M*=22.35, *SD*= 2.62)					
(Klevberg & Anderson, 2002)	12 undergraduate students (*M*= 26 yrs 6, *SD*=3 yrs, 6 m) 13 children (*M*=4 yrs 6 m, *SD*=2 m)	Compare how children and adults perceived *affordances* for upright stance when information was available either visually or haptically; Determine if children were prone to overestimate their ability to perform a basic postural task; Determine if the degree of overestimation was related to the perceptual system that was used to make the judgment	**Upright stance**	Participants judged, by looking at a platform or by exploring it haptically with a dowel, whether they could stand on it (yes/no)	**Perceptual response (Yes/no)** **Confidence judgments**	All participants showed close agreement between perceptual judgments and action capabilities in the visual condition; Children overestimated their ability to stand on the steeper slopes, took equal amounts of time to make their judgments across all slopes, and were equally confident in their judgments across all slopes; Adults took longer to respond and were less confident in the haptic condition whereas children had similar response times and were equally confident

Table 3 - Studies on estimation and real performance in children and adults

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
						in both conditions; Adults were more accurate than children at judging the *affordances* for upright stance, took longer to respond closer to the actual action boundary, and were less confident closer to the action boundary
(Plumert, 1995)	20 six year-olds (*M*= 6 yrs 3 m, range = 6 yrs to 6 yrs 10 m); 20 eight year-olds (*M*= 8 yrs 6 m, range = 8 yrs 2 m to 8 yrs 11m); 20 adults	Examine: whether the age groups differed in the accuracy of their judgments and decision times; How individual differences were related to accidental injuries	**Vertical reach** **Horizontal reach** **Stepping** **Clearance**	Participants decided whether or not they could perform each one of the 4 tasks (yes/no)	**Error tendency**	Children (6 and 8 years) overestimated their ability to perform tasks that were just and well-beyond their ability; Adults had difficulty making judgments just-beyond; Children (6 years) who were less accurate in judging their ability had experienced more accidents
	24 six year-olds (*M*= 6 yrs 4 m, range = 6 yrs 1m to 6 yrs 11 m);	Analyze: how experiences of success and failure influenced the accuracy of judgments;		Children could practice the action four times without making any judgments		Children (6 and 8 years) were more accurate in judging tasks that were within their ability; but the younger children overestimated their ability to

Table 3 - Studies on estimation and real performance in children and adults

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
	24 eight year-olds (*M*= 8 yrs 4 m, range = 8 yrs 1m to 8 yrs 11m);	How individual differences were related to accidental injuries				perform tasks that were beyond their ability; Older children (8 years) were more accurate for tasks that were well-beyond than just-beyond; Children (8 years) benefited from prior experience into subsequent decision and exercised more caution in decisions about just-within their ability; Overestimation was associated with accidental injuries for 6 years but not for 8 years
(Rochat, 1995)	14 three year-olds (*M*= 3 yrs 10 m, range = 41 to 53 m); 15 four year-olds (*M*= 4 yrs 11 m, range = 54 to 65 m); 14 five-year-olds	Examine if children: Differentiate between what is reachable for themselves and for others* (the experimenter); Perceive the effectivities of their own body as unique compared with	**Horizontal reach** **Vertical reach**	Participants judged their reach and that of the experimenter (yes/no) Participants and experimenter sat across each other at a table with an apple placed between them; Experimenter and children were under the apparatus and	**Absolute judgments** **Relative accuracy**	From 3 years, children differentiate what an object affords for themselves and for others; Children of all ages tend to attribute more reachability to the experimenter; Both children and adults underestimated the

Table 3 - Studies on estimation and real performance in children and adults

References (Authors, year)	Participants	Purpose	Assessed skill	Procedure	Error measure variables	Findings
	(*M*= 5 yrs 10 m, range = 66 to 78 m); 24 adults (range 17-21 yrs) *Experimenter**	that of the others; Analyze how accurate children are, when compared with adults, in perceiving what is reachable for themselves and for others, as a function of age		children judge their reach: with both feet flat on the ground (vertical situation), and while standing on tip toes (vertical/toes situation)		reachability of the experimenter and overestimate their own reachability (horizontal); Children tend to underestimate their reachability; adults tend to be more accurate (vertical) 3 years and 4 years children showed an increase of their underestimation using tip toes

m – months; yrs – years; * *affordances for the other*

2.4.4. Question 1: Which movement skill tasks have been used to assess estimation?

The manipulative skill reaching, in a vertical (upright posture) or horizontal conditions, was the outcome of interest for several studies (*e.g.,* Gabbard, Caçola, & Cordova, 2008; Johnson, & Wade, 2007). Five articles used Plumert's protocol (Helseth et al., 2013; Plumert, 1995; Plumert, & Schwebel, 1997; Schwebel, & Plumert, 1999; Schwebel, & Bounds, 2003). The protocol, besides including vertical reach and horizontal reach from a squatting position, comprises stepping (*i.e.,* stepping across two parallel sticks) and clearance (*i.e.,* sliding under a bar) abilities (Plumert, 1995). Sitting (Johnson, & Wade, 2007), stair climbing (Cesari et al., 2003) and upright stance (Klevberg, & Anderson, 2002) were other motor skills of interest. Only one study considered OC competence (striking a stationary ball, stationary dribble, kicking, catching, overhand throwing, and underhand rolling) (Barnett, Ridgers, & Salmon, 2014) and used a pictorial instrument to assess perceived OC displaying outcomes in terms of lower/high perceived competence rather than less/more accurate.

2.4.5. Question 2: How are estimations evaluated? (*i.e.,* dichotomous yes or no questions *vs*. quantitative measurements)

In most studies estimations were evaluated by *yes/no* verbal questions. Participants stood adjacent to the apparatus and gave a *yes/no* response, indicating whether or not they could perform the task (*e.g.,* Caçola, & Gabbard, 2012; Klevberg, & Anderson, 2002; Plumert, 1995; Rochat, 1995). In other studies, participants judged their maximum reaching distance by a *stop* command (Johnson, & Wade, 2007; 2009). In one study, participants selected the set of stairs that they thought they could climb (Cesari et al., 2003). In the study of Cordova and Gabbard (2011a), the actual maximum reach was determined by an oral response of distance estimation. Children and adults were asked to estimate how far the stimulus was in reference to the actual reach, in a range of -3 to +3. One of the twenty studies presented a pictorial self-reported instrument, which matched the real skills tasks, to assess perceived OC competence (Barnett et al., 2014). For each OC skill, boys and girls were provided with two pictures illustrating boys and girls cartoon figures: a *good* picture, depicting a child who was competent in the skill, and a *poor* picture depicting lower competence in the skill. Children were firstly required to choose which picture was most like them, and afterwards they were given two additional options, verbally, resulting in four possible options for each skill. The scores were summed into a perceived OC score (Barnett et al., 2014).

2.4.6. Question 3: Does estimation accuracy improve with age?

There is evidence that younger children make relatively inaccurate estimations of their real performance in comparison to older children and adults, particularly in some tasks such as horizontal reaching (Caçola, & Gabbard, 2012; Cordova, & Gabbard, 2011a, 2011b; Gabbard, Cordova, & Ammar, 2007; Gabbard, & Cordova, 2012). Cesari and colleagues (2003) studied a stair climbing task with children, young adults and older adults, and concluded that the large majority of the participants underestimated their ability but overestimations were more frequent in children than in the other groups (children: 23%; young adults: 7%, older adults: 0%). Young adults were the less accurate group (mean error) while the older adults were the most accurate. Klevberg and Anderson (2002) compared how children and adults perceived *affordances* for upright stance when information was available visually or haptically. The authors concluded that adults were more accurate than children, and children overestimated their ability. When making estimations for different motor skills (horizontal reach from a squatting position, vertical reach, stepping, and clearance) at four levels of difficulty in relation to participant's maximum level of ability (well within, just within, just beyond and well beyond), findings indicated that children and adults correctly estimated tasks that were within their ability, but children were more likely to overestimate tasks that were beyond their ability (Plumert, 1995). Plumert's study (1995) also considered how experience influenced the accuracy of estimations. When children were given experience with the tasks before the test trials, 8 year-olds but not 6 years-olds benefited from that experience. Rochat (1995) investigated the ability of adults and 3- to 5 year-olds children to judge reaching in horizontal and vertical conditions. In the horizontal reaching condition, all age groups tended to overestimate their ability but adults were in general more accurate than children. In the vertical reaching condition, children tended do underestimate their reachability and adults were, again, more accurate than children.

2.4.7. Question 4: Which variables are used to measure the estimation error?

Error measures were calculated in all twenty studies for the analysis of judgment accuracy. Collectively, the studies present varied error variables (see Tables 1-3) but with the same purpose: to determine the general direction of error in terms of bias (*i.e.,* overestimation, accurate or underestimation) and to determine the accuracy of the estimation (*i.e.*, deviation from the real measure), in cm (*e.g.,* Cesari et al., 2003; Johnson, & Wade, 2007), % (*e.g.*, Linkenauger et al., 2012) or in a perceptual response yes/no (Klevberg, & Anderson, 2002).

2.5. Strengths and Limitations

This systematic review was limited to English language literature and published studies were retrieved for a (nearly) 20-years period, so relevant studies published before 1995 and/or in other languages might have been missed. Despite the limitations, this review has the advantage of using a systematic rather than a narrative approach. It is the first review that reports the relationship between estimated and real performance in tasks in which the estimated measure matched the real assessed performance. The inclusion *criteria* combined studies with different participants and various research designs, allowing the extraction of extensive detailed information from each article. Although the studies included in this review were conducted on different motor skills, using different procedures and designs, as well as different assessments and measures of the estimations, there is a clear trend that adults are more accurate in their estimation. Future review authors might consider looking for unpublished literature. Although these sources might lack scientific rigor, they can still be useful by reporting other assessed motor skills and provide more findings on children's estimation.

2.6. Concluding Remarks and Suggestions for Future Research

Literature dealing with relation between estimated and real motor performance in children and adults, has not, to this date, been critically reviewed. Here we synthesized the findings in this area by a careful choice of inclusion parameters.

Regarding the relationship between estimated and real motor performance, results from the reviewed studies indicate that children are, in generally, less accurate than adults and that they systematically overestimate their own ability for different skills. This overestimation tendency has been previously reported by studies that evaluated perceived competence as a psychological construct (Harter, 1982; Harter, & Pike, 1984). It is considered normal for children to overestimate their motor competence because of cognitive limitations that make it difficult to distingue between their ideal and their real ability (Harter, 1999).

However, conclusions about children's overestimation tendency should be interpreted with caution. Only a few studies from the current systematic review looked at locomotor, object control or stability skills, and for this reason it is difficult to ascertain if the overestimation tendency in childhood also occurs for those motor skills. Most studies in this area regard manipulative skills, namely reaching in vertical or horizontal conditions. In fact, humans are unique in their ability to manipulate objects (Haywood, Roberton, & Getchell, 2012) and that might be one reason for the greater amount of studies that have used reaching or grasping tasks. The lack of studies meeting the inclusion *criteria* for other skills possibly limits the conclusiveness of the present findings.

Future research that examines different motor skills, particularly those skills that establish the motor repertoire of childhood, should be a priority in order to better understand how accurate children are in estimating different motor skills. It is important to investigate the causal mechanisms that lead to overestimation in childhood, and how overestimation has an impact on children development and, particularly, their motor development.

Given the established association between the overestimation tendency and accidental injuries in children (Plumert, 1995), intervention programs, which provide developmentally appropriate experiences and opportunities, targeting to improve judgments accuracy, should be considered at all ages. During childhood it is important to promote movement activities for children with the aim of enhancing the development of fundamental movement skills, but also the ability to make more accurate judgments about their own physical abilities.

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CHAPTER 3

RELATIONSHIP BETWEEN ESTIMATION AND REAL PERFORMANCE IN SCHOOL-AGE CHILDREN

STUDY 1

DIFFERENCES BETWEEN ESTIMATION AND REAL PERFORMANCE IN SCHOOL-AGE CHILDREN: MAXIMUM STANDING LONG JUMP

STUDY 2

DIFFERENCES BETWEEN ESTIMATION AND REAL PERFORMANCE IN SCHOOL-AGE CHILDREN: MAXIMUM THROWING AND KICKING

STUDY 3

DIFFERENCES BETWEEN ESTIMATION AND REAL PERFORMANCE IN SCHOOL-AGE CHILDREN: MAXIMUM WALKING BACKWARDS ON A BALANCE BEAM

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Relationship Between Estimation And Real Performance In School-age Children

Abstract

Observations in studies of estimation compared to actual performance in motor skills revealed that children have a tendency to overestimate the maximum distance at which an action can be performed. To our knowledge, the existing studies deal mostly with manipulative motor tasks (reaching). The present investigation addressed a locomotor (Study 1), a manipulative (Study 2), and stability (Study 3) skills. To 143 girls and 160 boys, with a mean age of 8.63 years (6.48-10.81 years; *SD*= 1.16), was given an estimation judgment task, followed by the action performance task. The accuracy of estimations was afterwards analyzed. None of the children presented development difficulties or learning disabilities, and all were attending age-appropriate classes. Children tended to systematically overestimate their fundamental movement skills, the more so for the fundamental manipulative skills (throwing: 73.60%; kicking: 63.37%) than for the fundamental stability skill (walking backwards: 45.21%). In addition, children's real and estimated performances were significantly associated for the four studied skills. The fact that children tend to overestimate their competences, may lead them to engage in activities that promote their skill proficiency, but can also be a problem in terms of child safety.

Keywords

Overestimation, standing long jump, throwing, kicking, walking backwards, action capabilities

3.1. Introduction

During development children learn to perceive their opportunities for action, or *affordances*, in different environments. The concept of *affordance* is a central tenet of the ecological approach to perception (J. J. Gibson, 1979), which captures the intrinsic relationship between a person's action capabilities and the relevant properties of the environment needed to support a particular action. From an early age, children learn how to cope with the existing *affordances* as their own body's proportions, strength, and capacity for balance are changing (E. J. Gibson, & Pick, 2000). They learn to detect for instance which surfaces afford crawling or walking (E. J. Gibson et al., 1987) or what objects are within their reach (van Hof, van der Kamp, & Savelsbergh, 2008). As E. Gibson and Pick underlined *"The task of infants is to learn about the affordances their world offers them"* (E. J. Gibson, & Pick, 2000, pg. 22). The rapid changes that occur in morphology and skills throughout the early stages of development keep on altering the existent *affordances* due to the changes in the fit between the child and the environment. For this reason, the perception of *affordances* during infancy and early childhood has been extensively studied (*e.g.,* Adolph, 1997).

As children continue to grow and develop, new actions and environmental opportunities emerge, and even if body changes do not occur as rapidly as they used to, the process of learning about *affordances* continues. However, the study of perception *affordances* in school-aged children has been less explored. The few studies that focus in these ages indicate that children tend to overestimate their action capabilities in postural (Klevberg, & Anderson, 2002), locomotor, and reaching tasks (Plumert, 1995); showing that children's estimates improve with age and are less accurate than adults' estimates (see Pufall, & Dunbar, 1992 for an exception).

Plumert (1995) found that 6 and 8 year-olds tend to overestimate their physical abilities in different tasks, such as reaching or sliding under a wooden bar, in which success was mostly determined by children's dimensions in relation the properties of the environment (*i.e.,* body-scaled *affordances*). The overestimation of action capabilities has also been reported, but in older children and adolescents during more complex tasks, such as bicycling across gaps in traffic in virtual reality scenarios, which depend mostly of children's behavior and not of their body dimensions (*i.e.,* action-scaled *affordances*) (Plumert, & Kearney, 2014). In some cases, the overestimation of physical abilities has been related with a greater frequency of accidental injuries (Plumert, 1995). Conversely, this overestimation is related to a positive judgment of self-ability and motor competence (*i.e.,* greater perceived physical competence), which seems to be fundamental for the development of children's motor skills.

Perceived physical competence has been studied as a psychological construct outside the scope of ecological psychology (Harter, 1978, 1982), based on self-reported measures developed to assess the perceived physical competence of children and adolescents (*e.g.,* Fox, & Corbin, 1989; Harter, 1982; Harter, & Pike, 1984; Marsh, 1996; Pérez, & Sanz, 2005; Whitehead, 1995). According to Harter (1982), until 8 year of age, children are often inaccurate in the perception of their physical ability, being unrealistically positive about their capabilities even when they have low motor competence. The impact of gender on perceived physical competence is small but there seems to be a tendency for boys to perceive themselves as more physically competent than girls (*e.g.,* Carroll, & Loumidis, 2001; Harter, 1982; Raudsepp, & Liblick, 2002; Robinson, 2010; Rudisill, Mahar, & Meaney, 1993). However, perceived motor competence, as a general measure based on a psychological construct, may not be related to children's physical abilities and real motor capabilities in a specific task. Gabbard, Caçola and Cordova (2009) examined the relationship between the estimation of reachability (measured by an experimental task) and the perceived motor competence (measured by Harter's scale), in 7-, 9-, and 11-year-old children. The authors concluded that the overestimation bias was not significantly associated with the level of general perceived motor competence, suggesting that future studies should be "*tied to context-specific measures of perceived abilities in relation to the specificity of the task*" (Gabbard, Cacola, & Cordova, 2009, pg. 157).

Fundamental Movement Skills (FMS) are categorized into three groups listed as fundamental locomotor skills (*e.g.,* running, jumping, hooping), fundamental manipulative skills (*e.g.,* throwing, catching, kicking), and fundamental stability skills (dynamic and static balance) (Gallahue, & Cleland-Donnelly, 2007).

In the present investigation, we have selected a context-specific measure to evaluate children's perception of an *affordance* that is related to their physical ability. The specific aim of this investigation was to provide further assessment of the systematic overestimation of estimated competence reported in the literature. In addition, we aimed at gathering information on the accuracy in different FMS, since the majority of the published studies address only reaching. The mastery of FMS is essential for the acquisition of more advanced and specific movement activities. In addition, a greater perceived motor competence in FMS has been related with the future adoption of active and healthier lifestyles (Stodden et al., 2008).

We have performed three assessments based on the same experimental paradigm: firstly children were asked to predict their ability, and secondly they were asked to perform those same tasks. No feedback from the evaluator or from the outcome of the actual performance was given to the children.

The purpose of Study 1 was to analyze the relationship between real and estimated maximum Standing Long Jump (SLJ). In Study 2 we analyzed the relationship between real and estimated maximum distance in two manipulative or object control skills: throwing and kicking. In Study 3 we examined the relationship between real and estimated Walking Backwards (WB) on a balance beam. We hypothesized that older children would be more accurate in their estimations than younger children, and that the overestimation tendency would be greater in younger than in older children, and greater in boys than in girls.

Study 1

Differences Between Estimation And Real Performance In School-age Children: Maximum Standing Long Jump

The first study was designed to assess children's accuracy in estimating their jumpability, that is, to assess if children could perceive *affordances* for the FMS of jumping (SLJ).
Block (1993) assessed 23 boys (ages 6-12 years) with Intellectual Disability (ID). Children were asked to accurately judge various distances that they would be able to jump by a SLJ. Estimations were compared to the real maximum jumping distance and absolute (magnitude) and algebraic (bias) differences were calculated. When compared to Typically Developing (TD) children, boys with ID made similar absolute differences and were fairly accurate at judging if a distance was jumpable. The author concluded that boys with ID and TD children had similar accuracy in their ability to judge if a distance can be jumped, although both groups of children tended to overestimate their jumping performance. A recent study (Liong, Ridgers, & Barnett, 2015) has examined the association between skill perception and actual fundamental movement skills in children. The evaluated movement skills were of the locomotor (run, hop, gallop, leap, horizontal jump, and slide) and object control (ball skills such as striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll) types. Children's skill perceptions were assessed using a pictorial instrument (Barnett, Ridgers, Zask, & Salmon, 2015) which directly compared the assessment of actual and perceived skills. In this assessment, a high score reflected a high perceived competence. The authors concluded that there were no significant correlations between girls's and boys's perceived and actual locomotor skills.
One study has explored the SLJ in adults (Lessard, Linkenauger, & Proffitt, 2009) in a perspective of perception of the action, concluding that perception of distance was action-specific since decreasing action capabilities (wearing ankle weights) made distances appear longer but only over extents upon which the action could be performed.

Jumping is a FMS, which is present in a variety of games and physical activities of children that occur in school, playgrounds, during household routine tasks, or during play or sports (Malina, Peña Reyes, Tan, & Little, 2011). The SLJ has been recognized as a good way to assess children's motor development (*e.g.*, Hands, 2008; Klein, Fröhlich, & Emrich, 2013; Pang, & Fong, 2009) and physical fitness performance (Malina et al., 2011; Morano, Colella, Robazza, Bortoli, & Capranica, 2011; Sacchetti et al., 2012) during school years. The measure of the horizontal distance jumped (product assessment) is frequently studied after children have refined the movement process. There is not a great difference between genders in what concerns the age of acquisition of the SLJ mature pattern, but, on average, boys can jump farther (Malina, 2004). However, the small differences found in childhood increase with age and moderate to large differences are found in adolescence (Thomas, & French, 1985).

Even though differences between genders have been reported in performance of the SLJ, the possible differences in the perception of this task remained to be explored. However, a greater overestimation tendency in boys would be consistent with their greater perception of physical competence, which has been reported by studies that evaluated perceived competence as a psychological construct.

3. 2. Methods

Participants

A sample of 303 children (160 boys and 143 girls), with ages between 6.48 years and 10.93 years (*M*=8.63 years; *SD*=1.16), participated in the study. Children were divided in three age groups: group 1 (*N*=102; age range: 6.48-8.01 years); group 2 (*N*=101; age range: 8.02-9.22 years); and group 3 (*N*=100; age range: 9.24-10.93 years). None of the children presented developmental difficulties or learning disabilities, and all attended age-appropriate classes. Prior informed consent from the parents and verbal assent from the children were obtained.

Measures and Procedure

The SLJ test was measured following standard procedures (Castro-Piñero et al., 2010; Chung, Chow, & Chung, 2013; Gontarev, Zivkovic, Velickovska, & Naumovski, 2014). The child was instructed to jump as far as possible from a standing start with feet slightly apart. The test was performed twice and the best score (measured in cm) was used for analysis. Before performing the SLJ, the child was asked to estimate his/her maximum jumping distance (see Fig. 2). During this estimation, participants stood behind a line, while the evaluator starting at the feet of the child, slowly and steadily unraveled a measuring tape until the child told her to stop, indicating the perceived maximum jumping distance (*i.e.,* the critical action boundaries). The child was allowed to make fine adjustments after the order to stop if he/she found it necessary. The task was conducted in a uniform floor with no marks that could help the child to memorize the estimated location.

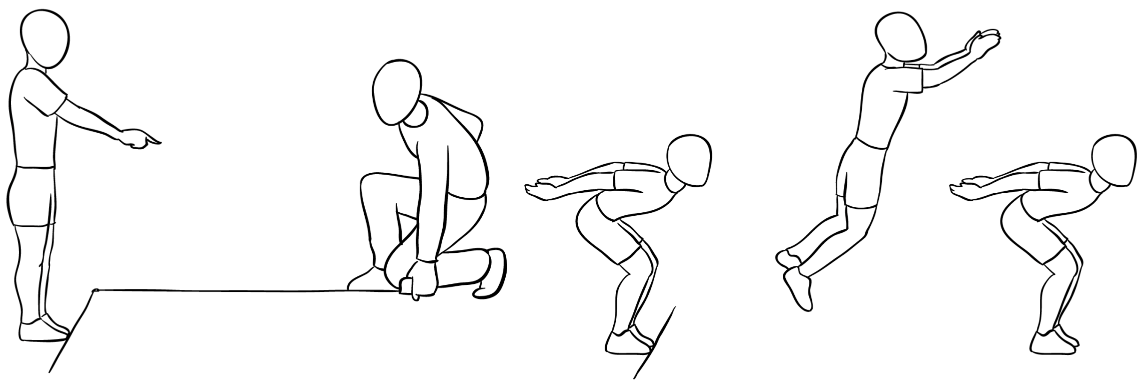

Figure 2 - Estimation (left) and performance (right) of the standing long jump task

Data collection and analysis

Absolute percent error, absolute error, and error tendency were calculated (*cf.*, Cordovil, & Barreiros, 2011). Absolute Percent Error (APE) (|1- estimation/real performance| × 100) is the amount of judgment error expressed as percentage of the real performance in the SLJ for each child. Absolute Error (AE) is the difference between the real maximum long jump and the estimated jump (|real performance – estimation|). These two variables indicate the discrepancy in cm between estimation and action, but not the under- or over estimation bias. Error Tendency (ET) (*i.e.,* frequency of overestimation, accuracy, and underestimation bias) indicates the direction of the error. A ±12 cm error was allowed for estimations to be considered accurate. This value was settled by taking the average variability of the set of SLJ data, and the children's foot size as *criteria*. Considering this, an overestimation occurred when the estimation was more than 12 cm above that of the real performance and an underestimation occurred when the estimation was less than 12 cm from the real performance.

Independent samples *t*-tests were used to compare differences in the real performance, estimation, and in the error variables (AE and APE) between genders. ANOVAs were used to examine the effect of age on SLJ, APE, and AE. Pearson's chi-square tests were used to determine differences in error tendency according to gender and age groups. Pearson correlations were used to examine relationships between the variables (real performance, estimation, and chronological age). A standard multiple linear regression, separated by gender, was calculated to predict real SLJ performance (dependent or outcome variable) based on chronological age and estimation (independent or predictor variables). Statistical significance was set at $p<.05$. Data analyses were conducted using SPSS (version 21).

3. 3. Results

Maximum Standing Long Jump: estimation and real performance

The maximum distance in SLJ was significantly greater in boys (M=128.36, SD=24.49, range 54-192 cm) than in girls (M=115.85, SD=24.89, range 49-174 cm) (t(301)= 4.40, p<.001). A main effect of age on SLJ was found, F(2, 300)=18.82, p<.001, η^2_p=.11. *Post hoc* analysis showed a statistically significant difference between the oldest age-group (9.24-10.93 years) and the other age groups (p<.001).

On average, boys estimated more (M=151.51, SD=30.91) than girls (M=128.47, SD=32.78). This difference was significant (t(301)=6.30, p<.001).

There was a significant and positive relationship between chronological age and maximum SLJ (r=.33, p<.001). After separating by gender, there was a significant association between boys' chronological age and real SLJ (r=.40, p<.001), and girls' chronological age and real SLJ (r=.30, p<.001).

Correlation analysis showed that there was a significant and positive association between SLJ and the estimation of SLJ (r=.37, p<.001). After separating by gender, there was a significant but weak association between boys' estimated and real SLJ (r=.37, p<.001), and girls' estimated and real SLJ (r=.25, p=.003).

Chronological age was not significantly associated with estimation of SLJ (r=.13, p=.24). When separating by gender, there was not a significant association between boys' chronological age and estimated SLJ (r=.10, p=.23). On the other hand, girls' chronological age and estimated SLJ was weakly but significantly associated (r=.21, p=.009).

All correlations, except those relating estimation and chronological age for all sample and for boys, were statistically significant.

Results of the standard multiple regression analyses were as follows:

Boys

A significant regression equation was found (*F*(2,157)=18.60, *p*<.001), with an R^2 of .192. The weighted combination of the predictor variables explained only 19.2% of the variance of real performance. Both estimation of SLJ and chronological age were significant predictors of real SLJ. As we can see by examining the Beta weights, estimation made the larger contribution to the prediction model (see Table 4).

Table 4 - Standard regression results for boys' standing long jump

Model	*b*	*SE-b*	Beta	Pearson *r*	*p*
Constant	47.015	14.368			
Estimation of SLJ	.255	.058	.322	.37**	<.001
Chronological age	4.979	1.535	.238	.40**	.001

Note: the dependent variable was SLJ real performance
R^2=.192, Adjusted R^2=.181
*p<.05, **p<.01

Girls

A significant regression equation was found (*F*(2,140)=17.88, *p*<.001), with an R^2 of .204. The weighted combination of the predictor variables explained only 20.4% of the variance of real performance. Both estimation of SLJ and chronological age were significant predictors of real SLJ. Contrarily to the boys, chronological age made the larger contribution to the prediction model (see Table 5).

Table 5 - Standard regression results for girls' standing long jump

Model	*b*	*SE-b*	Beta	Pearson *r*	*p*
Constant	24.864	15.382			
Estimation of SLJ	.161	.058	.212	.25**	.006
Chronological age	8.098	1.627	.377	.30**	<.001

Note: the dependent variable was SLJ real performance
R^2=.204, Adjusted R^2=.192
*p<.05, **p<.01

Magnitude of error: Absolute Error and Absolute Percent Error

The descriptive statistics by gender and age groups for estimation of SLJ, SLJ, AE and APE is presented in Table 6. No statistically significant gender differences were observed in AE (*t(301)*=.42, *p*=.68) and APE (*t(301)*=-.58, *p*=.56). No age-related differences were found for AE, *F*(2, 300)=2.61, *p*=.08, η^2_p=.02. However a main effect of age on APE, *F*(2, 300)=4.38, p=.01, η^2_p=.03, was found. *Post hoc* analysis shows a statistically significance difference between age groups 2 (8.02-9.22 years), and 3 (9.24-10.93 years) (p=.01).

Table 6 - Descriptive statistics (mean and *SD*) divided by gender and age groups for estimating of standing long jump (in cm), standing long jump (in cm), absolute error (in cm), and absolute percent error (in %)

Variable	Gender		Age groups (years)			Overall sample
	Boys (*n*=160) *M* (*SD*)	Girls (n=143) *M* (*SD*)	6.48-8.01 (*n*= 102) *M* (*SD*)	8.02-9.22 (*n*=101) *M* (*SD*)	9.24-10.93 (*n*= 100) *M* (*SD*)	(*n*=303)
ESLJ (cm)	151.51 (30.91)	128.47 (32.78)	134.72 (33.17)	140.14 (37.25)	147.18 (29.61)	140.64 (33.78)
SLJ (cm)	128.36 (24.49)	115.85 (24.89)	113.22 (21.38)	120.63 (27.45)	133.73 (22.88)	122.46 (25.42)
AE (cm)	29.36 (25.80)	28.13 (25.50)	29.03 (26.32)	32.73 (29.14)	24.53 (20.09)	28.78 (25.62)
APE (%)	25.63 (29.65)	27.72 (32.68)	27.59 (28.10)	32.44 (41.18)	19.73 (18.58)	26.61 (31.08)

ESLJ – Estimating of Standing Long Jump; SLJ – Standing Long Jump; AE – Absolute error; APE – Absolute percent error

Error Tendency

Most children (56.11%) have a tendency to overestimate their jump performance (see Table 7). About 28.05% of the children are able to accurately estimate their jump and 15.84% underestimate it. A scatter plot of children's estimation and real SLJ is presented in Figure 3.

Table 7 - Percentages of error tendency in the estimation of standing long jump, divided by gender and age groups

Error Tendency (%)	Gender		Age groups (years)			Overall sample
	Boys (*n*=160)	Girls (n=143)	6.48-8.01 (*n*=102)	8.02-9.22 (*n*=101)	9.24-10.93 (*n*=100)	(*n*=303)
Underestimation	10.00	22.38	12.75	15.84	19.00	15.84
Accurate	26.88	29.37	28.43	24.75	31.00	28.05
Overestimation	63.13	48.25	58.82	59.41	50.00	56.11

The results show a significant association between the ET and gender, $\chi^2(2)$=10.45, p=.005. Despite both genders showing an overestimation tendency, this overestimation tendency is slightly greater in boys (63.13% *vs.* 48.25%) and less boys than girls underestimated their action capabilities (22.38% *vs.* 10.00%). Even though there seems to be a decrease in the overestimation bias with aging, there were no significant associations between ET and the age groups (χ^2 (4)=2.95, *p*=.56).

3. 4. Discussion

The findings of this study show a discrepancy between real and estimated maximum SLJ, with most children in all ages being convinced that they are able to jump more than their actual maximum capability (56.11%). Overestimation can lead to failure and even injuries (Plumert, 1995; Plumert, & Schwebel, 1997). Because the tasks were performed in a risk-free environment, and children did not have to deal with the consequences of overestimating their jumping ability, the overestimation may not be generalizable to realistically risky real-life situations.

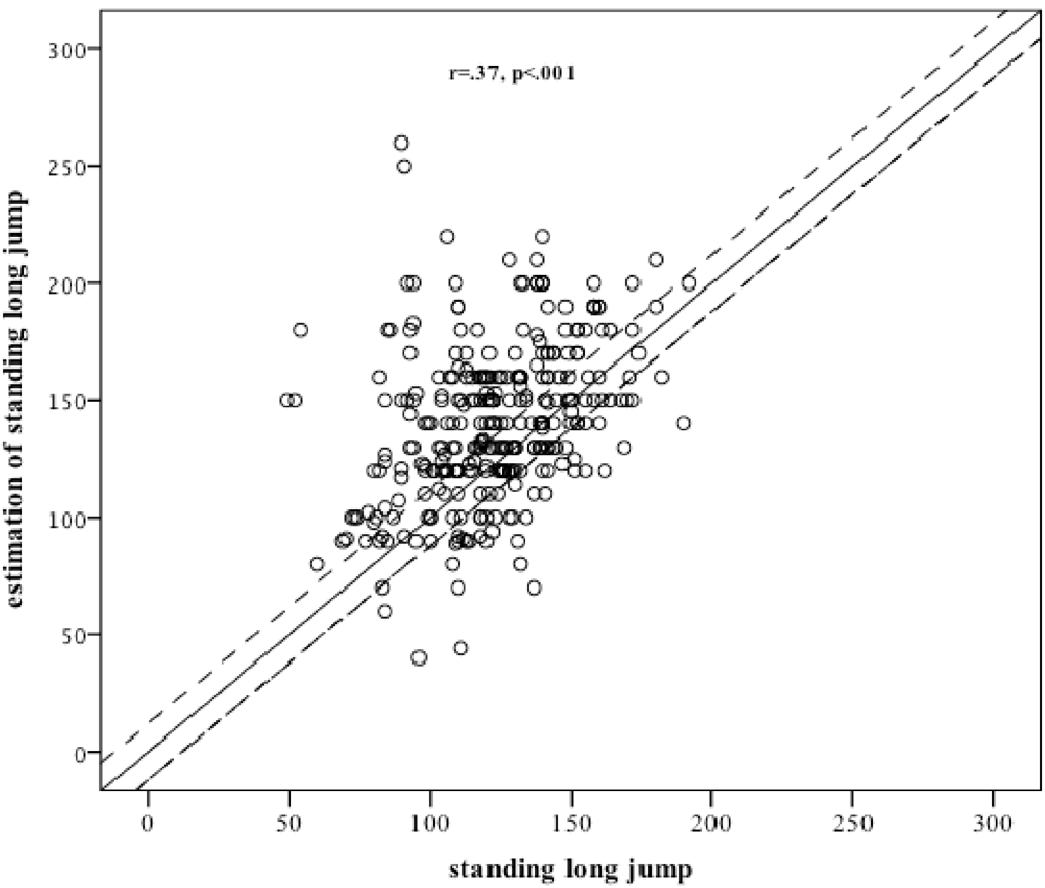

Figure 3 - Scatter plot of children's estimation and real standing long jump (in cm). The continuous line represents perfect agreement between estimation and real standing long jump (*n*=13). The dashed lines indicate the interval within which the jump is considered accurate (±12 cm). Estimations above the top dashed line were considered overestimations. Estimations below the bottom dashed line were considered underestimations

Block (1990, cit in Block, 1993) suggested a developmental trend for TD children, where younger children (3 years) tend to overestimate (83%) and older children (11 years) tend to underestimate (63%). 7 year-old children are said to be in transition (52% of overestimation). Block's study (1993) also suggests a tendency for overestimation bias in ID children (65%) with an absolute difference (15.1 cm), which is similar to that of TD children (3 years: 12.6 cm; 7 years: 12.5 cm; 11 years: 14.4 cm) (Block 1990, cit in Block 1993). This value is considerably lower than the mean AE of our overall sample (28.78 cm). In our study we found a weak association (r=.37) between estimation and real competence, whereas Block (1993) found a strong correlation (r=.90), indicating that boys with ID are aware of their jump ability when determining if they can or not perform the SLJ. We believe that these differences are due to different followed protocol. Do to the fact that children in Block's study were ID children, they were given demonstrations and received training until they demonstrated understanding of the actions to be performed, that is, to independently make judgments for a total of 24 to 36 judgments. The real maximum jumping distance was measured after all judgments had been taken. In the study reported here, children were not given demonstrations and training and only one judgment was asked. In Block's (1993) study, children could accurately judge (yes/no response) whether several distances (presented randomly) could be jumped. In our study, children indicated an estimation concerning to the maximum performance by a stop command and made fine adjustments until satisfied, which were followed by the jump.

Liong, Ridgers and Barnett (2015) found that children's perceived and actual locomotor skills, assessed by six locomotor skills (running, horizontal jumping, hopping, sliding, leaping, galloping), were not significant associated (r=.03). In our study, we found that, children's, boys' and girls' estimated and real locomotor competence (assessed through the SLJ) were weakly significantly associated. It was also found that the weighted combination of estimation and chronological age explained approximately 20% of the variance of real SLJ performance, for both genders, which leaves about 80% of the variability still to be accounted for by other variables. It is interesting to note that the SLJ real performance for the girls was primarily predicted by chronological age and, to a lesser extent, by estimation. On the other hand, the opposite was found for the boys, where estimation received the strongest weight in the model. These findings were not comparable with other reported studies, because Liong and colleagues (2015) found no association between children's perceived and actual locomotor skills (six perceived and real skills), and Barnett et al. (2014) only looked into the relationship between perceived and actual object control competences.

In this study, a significant association between the ET and gender was also found. Boys have a greater tendency to overestimate their SLJ ability and significantly less boys than girls underestimate their performance. Girls apparently were more cautions of their estimations in an effort not to failure neither injury, whereas boys tend to overestimate, that is, may have been less cautions in their estimations of how far they could jump. The overestimation may lead to unsuccessful action or injuries, whereas underestimation may lead to a cautions behavior (Plumert, 1995; Schwebel, & Plumert, 1999).

When analyzing the relation between maximum SLJ and its estimation according to age, we can verify that all age groups tend to overestimate their jumping ability, but with age the frequency of accurate estimations and of underestimations increases slightly. With increasing age, children show a tendency to become more accurate in the judgment of their physical abilities (*e.g.,* Klevberg, & Anderson, 2002; Plumert, 1995).

Regarding the AE and APE, there was a decrease in both errors, which did not reach significance, between the youngest and the oldest age groups. Unexpectedly, in the present study, the intermediate age group (8.02 - 9.22 years) displayed higher AE and APE than the other two age groups. In fact, children from the intermediate age group, were significantly less accurate (*i.e.,* greater APE values) than children from the oldest age group. Such behavior has not been reported previously. However, when comparing the intermediate age group with the younger children, it was found that the latter show a slightly better performance. One possible explanation may be that the children in the intermediate age group have excessive self-confidence in their abilities compared to the younger children, but they do not have yet mastered as much in their motor skills as the older ones have. This excess of confidence may be the driving force for the large increase in the jumping performance that might be about to happen. In fact, the increase in the SLJ performance between the first and second age groups was approximately 7 cm, whereas between the second and third age groups it was approximately 13 cm (almost double). It is interesting to note that a similar study performed in adults (Lessard, Linkenauger, & Proffitt, 2009) has shown an estimation error of about 28% over extents considered possible to jump (*i.e.*, mean ratio of estimated over actual gap distance = 1.28). While this is very similar to the APE of the overall sample in this study (26.61%), there is a difference in the error towards the oldest age group (19.73%). This difference might be explained due to the different goals and methodologies between the two studies. In Lessard's et al. (2009)

study participants had to estimate a distance in cm for what they considered possible or impossible jumping distances (*i.e.,* mainly a perceptive task considering different distances); while in the present study, participants had to estimate their maximum jumping ability distance, which was compared to their actual maximum jump (*i.e.*, a perceptive and motor task of an action limit). Despite these differences, the results of the two studies indicate that both distance and actual jumping ability seem to be generally overestimated in SLJ tasks.

Our findings also suggest that on average, older children and boys achieve greater distances in SLJ than younger children and girls. Previous research confirms age and gender differences in motor skills, specifically in motor tasks of lower muscular strength assessment through the SLJ (Colella, Morano, Robazza, & Bortoli, 2009; Raudsepp, & Paasuke, 1995; Sacchetti et al., 2012; Ulbrich et al., 2007).

A meta-analysis research conducted by Thomas and French (1985) focusing on gender differences in children and adolescents' performance of 20 physical skills, found gender differences for the SLJ related to age, favoring boys in early childhood. There were small differences in favor of boys in preschool children (d=.25 to .50), increasing differences through school-age (d=.50 to 1.0), and large differences in adolescence (d=1.0 to 2.0).

Concerning the age of our sample, recent studies conducted by Gontarev et al. (2014), and Chung et al. (2013) found differences between genders for the SLJ, with boys displaying better results than girls, for all age groups assessed. The differences became larger with age.

These results indicated that children demonstrate a tendency to overestimate the maximum distance they can jump and underestimation is more frequent in girls.

Study 2

Differences Between Estimation And Real Performance In School-age Children: Maximum Throwing And Kicking

This second study aimed at examining the perception of two fundamental manipulative skills (throwing and kicking) and to compare them with real performance.

To our knowledge, only two studies have examined the relationship between real and perceived Object Control (OC) in children (Barnett, Ridgers, & Salmon, 2014; Liong, Ridgers, Barnett, 2015). In both studies, the assessed skills requiring OC were: striking, dribbling, kicking, caching, throwing, and rolling a ball. Despite the fact that the perceived OC competence, for both studies (Barnett et al., 2014; Liong et al., 2015), was assessed using a pictorial instrument (Barnett, Ridgers, Zask, & Salmon, 2015), the perception skills matched the actual assessed skill. In the first study, it has been found that girls' perceived competence is lower than that of boys, perceived OC competence is positively associated with OC competence, and that this relationship does not differ by gender. Liong and collaborators (2015) found that children's and boy's perception were associated with their actual OC ability.

Manipulative skills, such as throwing and kicking, are generally the first forms of gross motor manipulation and are generally considered to be fundamental manipulative skills that are essential to purposeful and controlled interactions with an object in the environment. The progress to a more mature stage in fundamental manipulative skills, which occurs at about 7 years of age, depends on environmental encouragement, opportunities for practice, and instruction. This more refined stage is necessary for the successful playing of many sports (Gallahue, & Cleland-Donnelly, 2007). The gender differences on manipulative skills, favoring boys (*e.g.,* Barnett, van Beurden, Morgan, Brooks, & Beard, 2010; Butterfield, Angell, & Mason, 2012), are probably related to socio-cultural influences on practice and appropriateness of activities that involve these skills (Malina, 2004).

Even though differences between genders have been reported in performance of the manipulative skills, the possible differences in the estimation of these skills with a quantitative measure remained to be studied. Presumably this will lead to greater overestimation tendency in boys, which would be consistent with the findings of Barnett and colleagues' study (2014).

3.5. Methods

Participants

Children participating in Study 2 were the same as Study 1.

Measures and Procedures

For the throwing condition, a mini soccer goal (120 cm × 80 cm) was placed 1 m above the floor on a table, and a softball was used. For the kicking condition, the mini soccer goal was placed on the floor, and a size 4 soccer ball was used. The floor was marked every 2 m, from 2 m to 20 m away from goal (see Fig. 4). In both tasks, the child stood upright in front of the goal and behind the 20 m line. From this position, the child was asked to go to the mark that he/she estimated to be the maximum distance to successfully throw/kick the ball into to the mini soccer goal. This distance was registered as the child's estimation. After that, the evaluator asked the child to throw/ kick the ball into the target. If the child succeeded, he/she was asked to throw/kick from a farther line. This procedure was repeated until the child failed the target. When the child failed (in any throw/kick position), he/she was asked to throw/kick from a closer line. This procedure was repeated until the child succeeded. The final successful position was the real distance recorded.

Data collection and analysis

Descriptive statistic (mean and standard deviation) for the variables throwing, kicking, Absolute Error (AE), Absolute Percent Error (APE), and Error Tendency (ET) (frequency and percentages) were computed. Before conducting the analysis, AE, APE, and ET were calculated (*cf.,* Cordovil, & Barreiros, 2011). AE is the difference between the real maximum distance in throwing or in kicking performance, and the maximum distance estimated (|real performance – estimation|). APE (|1- estimation/real performance| × 100) is the amount of judgment error expressed as percentage of the real performance in the throwing/kicking for each child. These two variables indicate the discrepancy in meters between perception and action, but not the under- or overestimation bias. Error tendency *(i.e.,* frequency of overestimation, accurate, and underestimation bias) indicates the error direction. An overestimation occurred when estimation was superior to the real performance; an underestimation occurred when the estimation was less than the real performance, and accurate estimation if the real performance was equal to the estimation. Independent samples t-tests were used to compare differences in real performance and estimation of throwing and kicking tasks, and in the error variables (AE and APE) between genders. Univariate analyses of variance (ANOVAs) were used to examine the effect of age on real performance, on APE and AE. Pearson's chi-square tests were used to determine differences in error tendency according to gender and age groups. Pearson correlations were used to examine relationships between the variables (estimation, real performance, and chronological age). A standard multiple regression, separated by gender, was conducted to predict real performance (dependent variable or outcome) based on chronological age and estimation (independent variables or predictor variables). Statistical significance was set at $p<.05$. Data analyses were conducted using SPSS (version 21).

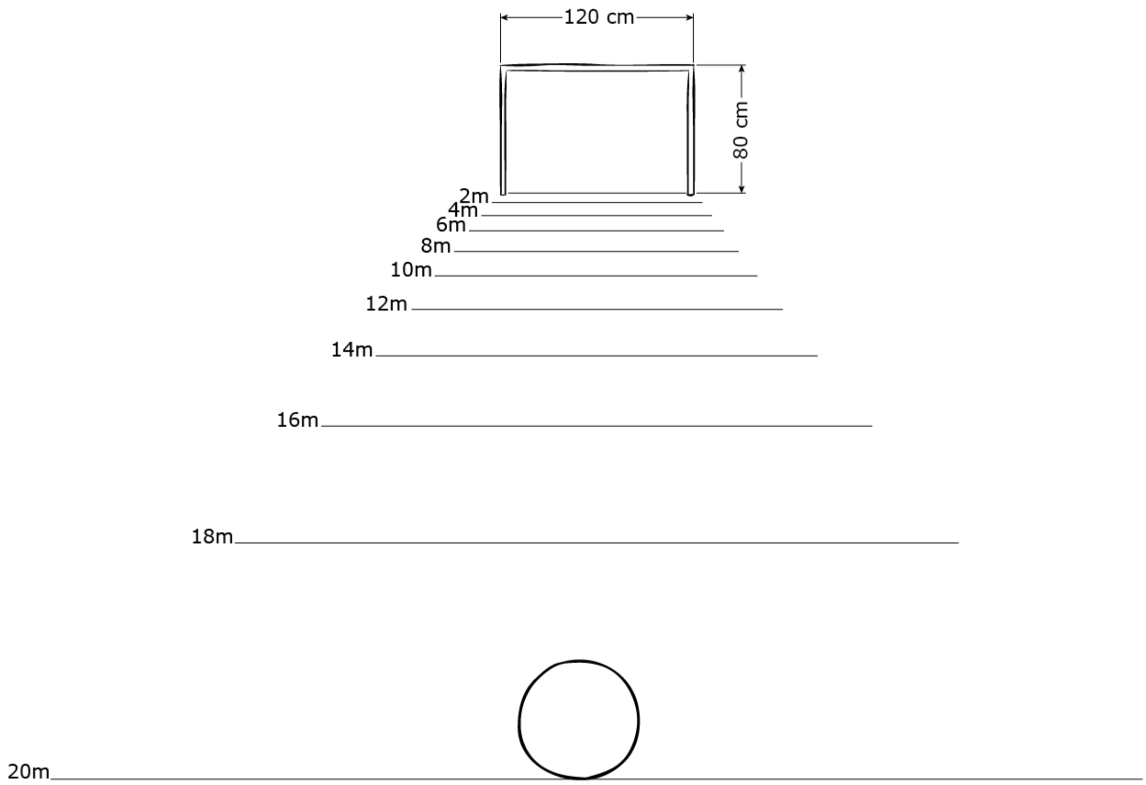

Figure 4 - Apparatus used for the estimation of the kicking task. The same marks and goal were used for the throwing task, but the goal was placed 1 m above the floor, on one table

3.6. Results

Throwing and Kicking: estimation and real performance

The descriptive statistics, divided in gender and age groups, for throwing and kicking are presented in Tables 8 and 13, respectively.

On average, boys showed a greater maximum throwing distance (M=5.53, SD=2.89, range 2-18 m) than girls (M=3.99, SD=2.16, range 2-12 m) (t(291,78)=5.28, $p<.001$). The maximum kicking distance was also greater in boys (M=7.06, SD=3.87, range 2-20 m) than in girls (M=5.50, SD=2.97, range 2-20 m) (t(294,37)=3.97, $p<.001$).

Boys' estimations of their maximum throwing distance was significantly greater (*M*=8.55, *SD*=3.92) than girls' estimation (*M*=6.43, *SD*=2.33) (*t*(263.396)=5.79, *p*<.001). The same tendency was true for the estimated maximum kicking distance (boys: *M*=9.60, *SD*=4.03; girls: *M*= 7.05, *SD*=2.83) (*t*(285,802)=6.42, *p*<.001).

Throwing and kicking real performances were weakly correlated (*r*=.27, *p*<.001). The estimations of maximum throwing and kicking distances were significantly correlated (*r*=.71, *p*<.001). Children's estimations and real performances were also found to be significantly and positively associated (throwing: *r*=.52, *p*<.001; kicking: *r*=.60, *p*<.001). After separating by gender, there was a significant association between boys' estimated and real competence (throwing: *r*=.53, *p*<.001; kicking: *r*=.59, *p*<.001), and girls' estimated and real competence (throwing: *r*=.34, *p*<.001; kicking: *r*=.55, *p*<.001).

Table 8 - Descriptive statistics (mean and *SD*) divided by gender and age groups for estimation of throwing (in m), throwing (in m), absolute error (in m) and absolute percent error (in %)

	Gender		Age groups (years)			Overall sample
Variable	Boys (*n*=160) *M* (*SD*)	Girls (n=143) *M* (*SD*)	6.48-8.01 (*n*= 102) *M* (*SD*)	8.02-9.22 (*n*=101) *M* (*SD*)	9.24-10.93 (*n*= 100) *M* (*SD*)	(*n*=303)
Throwing's estimation (m)	8.55 (3.92)	6.43 (2.33)	7.10 (3.36)	7.05 (3.13)	8.52 (3.60)	7.55 (3.43)
Throwing (m)	5.53 (2.89)	3.99 (2.16)	4.11 (2.39)	4.55 (2.25)	5.74 (3.10)	4.80 (2.68)
AE (m)	3.40 (3.03)	2.78 (2.29)	3.29 (2.66)	2.81 (2.52)	3.22 (2.65)	3.11 (2.69)
APE (%)	87.25 (96.75)	102.62 (103.77)	115.16 (117.30)	86.06 (87.79)	81.97 (90.36)	94.50 (100.25)

AE – Absolute error; APE –Absolute percent error

The ANOVAs confirmed a main effect of age in the throwing, *F*(2,300)=6.93, *p*=.001, η^2_p=.04, and kicking, *F*(2,300)=10.50, *p*<.001, η^2_p=.06 tasks. *Post hoc* analysis showed a statistically significant difference between the oldest age group (group 3) and the two younger groups for both tasks (throwing - group 1: *p*=.004; group 2: *p*<.001; kicking - group 1: *p*=.008; group 2: *p*=.002).

There was also a significant but weak relationship between the chronological age with both tasks: throwing (*r*=.25, p<.001), and kicking (*r*=.17, *p*=.003). After separating by gender, there was a significant association between boys' chronological age and real throwing (*r*=.34, *p*<.001), and girls' chronological age and real throwing (*r*=.18, *p*=.03). The kicking skill was also related with boys' chronological age (*r*=.24, *p*=.03). There was no significant association between girls' chronological age and real kicking (*r*=.11, *p*=.18).

Chronological age was weakly associated with the estimation of throwing (*r*=.15, *p*=.01). After separating by gender, there was not a significant association between girls' chronological age and estimated throwing (*r*=-.01, *p*=.90); however, boys' chronological age and estimated throwing was weakly but significantly associated (*r*=.27, *p*=.001). Children's estimated kicking and chronological age were positively associated (*r*=.21, *p*<.001). When considering gender, there was a significant association between boys' estimated kicking and chronological age (*r*=.34, *p*<.001); however, there was no significant association between girls' estimated kicking and chronological age (*r*=.10, *p*=.25).

All correlations, except for the one between estimation of throwing and chronological age for girls, were statistically significant. For the kicking, all correlations, except those relating estimation and chronological age for girls, and real and chronological age for girls, were statistically significant.

For the throwing, the results of the standard multiple regression analyses were as follows:

Boys

The predictor model was statistically significant (*F*(2,157)=38.07, *p*<.001), and accounted for approximately 33% of the variance of throwing (R^2=.327). Both estimation of throwing and chronological age were significant predictors of real performance. As can be seen from the Beta weights, real throwing was primarily predicted by estimation and to a lesser extent by chronological age (see Table 9).

Table 9 - Standard regression results for boys' throwing

Model	*b*	*SE-b*	Beta	Pearson *r*	*p*
Constant	-1.996	1.404			
Estimation of throwing	.352	.050	.476	.53**	<.001
Chronological age	.526	.168	.213	.34**	.002

Note: the dependent variable was throwing real performance
R^2=.327, Adjusted R^2=.318
**p*<.05, ***p*<.01

Girls

A significant regression equation was found (*F*(2,140)=12.575, *p*<.001), with an R^2 of .152, that is, the weighted combination of the predictor variables explained only 15.2% of the variance of real performance. Both estimation of throwing and chronological age, were significant predictors of real performance. As for the boys, estimation made the larger contribution to the prediction model (see Table 10).

Table 10 - Standard regression results for girls' throwing

Model	*b*	*SE-b*	Beta	Pearson *r*	*p*
Constant	-1.056	1.353			
Estimation of throwing	.320	.072	.346	.34**	<.001
Chronological age	.343	.146	.185	.18**	.019

Note: the dependent variable was throwing real performance
R^2=.152, Adjusted R^2=.140
*p<.05, **p<.01

For the kicking performance, results of the standard multiple regression analyses were as follows:

Boys

The predictor model was statistically significant ($F(2,157)=41.578$, $p<.001$), and accounted for approximately 35% of the variance of throwing (R^2=.346). Only the estimation was a significant predictor of real kicking (see Table 11).

Table 11 - Standard regression results for boys' kicking

Model	*b*	*SE-b*	Beta	Pearson *r*	*p*
Constant	.502	1.850			
Estimation of kicking	.549	.066	.572	.59**	<.001
Chronological age	.150	.227	.045	.24**	.509

Note: the dependent variable was kicking real performance
R^2=.346, Adjusted R^2=.338
*p<.05, **p<.01

Girls

A significant regression equation was found ($F(2,140)=30.064$, $p<.001$), with an R^2 of .300, that is, the proportion of the variance explained by the model is 30%. As for the boys, only the estimation was a significant predictor of real kicking (see Table 12).

Table 12 - Standard regression results for girls' kicking

Model	*b*	*SE-b*	Beta	Pearson *r*	*p*
Constant	.168	1.627			
Estimation of kicking	.564	.074	.539	.55**	<.001
Chronological age	.156	.182	.061	.11	.393

Note: the dependent variable was kicking real performance
R^2=.300, Adjusted R^2=.290
*p<.05, **p<.01

Magnitude of error: Absolute Error and Absolute Percent Error

The descriptive statistics for AE and APE, divided according to gender and age, for the throwing and kicking tasks are depicted in Tables 8 and 13, respectively.

Regarding AE, girls were more accurate than boys (*i.e.*, lower error) in both throwing

(t(289,201)=2.04, p=.04), and kicking tasks (t(291,76)=3.53, p<.001). However, the difference in the accuracy of throwing estimations disappeared when APE (t(301)= -1.33, p=.18) was considered instead of AE. For the kicking task, girls' accuracy was greater than that of boys even when considering the APE (t(279,18)=2.09, p=.04).

No significant age effects were found on AE for the throwing, F(2,300)=.95, p=.39, η^2_p=.0006, and kicking tasks, F(2,300)=.56, p=.57, η^2_p=.0037. However, a main age effect was found for the APE of throwing, F(2,300)=3.36, p=.04, η^2_p=.02, and kicking, F(2,300)=4.37, p=.01, η^2_p=.03. *Post hoc* analysis showed a statistically significant difference between the oldest (group 3) and the youngest (group 1) age groups, for throwing's APE (p=.048). For kicking, differences in APE were significant between age groups 1 and 2 (p=.04), and between age groups 2 and 3 (p=.02). No significant relationship was found between the APE of throwing and kicking (p=.57).

Table 13 - Descriptive statistics (mean and *SD*) divided by gender and age groups for estimation of kicking (in m), kicking (in m), absolute error (in m) and absolute percent error (in %)

	Gender		Age groups (years)			Overall sample
Variable	Boys (*n*=160) *M* (*SD*)	Girls (n=143) *M* (*SD*)	6.48-8.01 (*n*= 102) *M* (*SD*)	8.02-9.22 (*n*=101) *M* (*SD*)	9.24-10.93 (*n*= 100) *M* (*SD*)	(*n*=303)
Kicking's estimation (m)	9.60 (4.03)	7.05 (2.83)	7.47 (2.84)	8.12 (3.71)	9.62 (4.23)	8.40 (3.74)
Kicking (m)	7.06 (3.87)	5.50 (2.97)	5.90 (2.75)	5.70 (3.35)	7.38 (4.22)	6.32 (3.56)
AE (m)	3.39 (2.80)	2.39 (2.08)	2.86 (2.26)	3.12 (2.95)	2.76 (2.35)	2.92 (2.54)
APE (%)	77.83 (93.78)	58.86 (62.53)	60.72 (57.18)	88.03 (103.88)	57.85 (72.16)	68.88 (80.99)

AE – Absolute error; APE –Absolute percent error

Error Tendency

Table 14 depicts the error tendency for throwing and Table 15 for kicking, divided by gender and age. Children in this study had a clear tendency to overestimate the maximum distance achieved in both manipulative tasks: 73.60% of the children overestimated their throwing ability and 63.37% overestimated their kicking ability. Boys had a slightly greater tendency to overestimate their throwing and kicking than girls, although these differences were not significant, χ^2 (2)=.07, p=.97 (throwing); χ^2 (2)=.20, p=.91 (kicking).

Table 14 - Percentages of error tendency in the estimation of throwing, divided by gender and age groups

Error Tendency (%)	Gender		Age groups (years)			Overall sample
	Boys (*n*=160)	Girls (n=143)	6.48-8.01 (*n*= 102)	8.02-9.22 (*n*=101)	9.24-10.93 (*n*= 100)	(*n*= 303)
Underestimation	50.00	50.00	35.00	30.00	35.00	6.60
Accurate	53.33	46.67	31.67	38.33	30.00	19.80
Overestimation	52.91	47.19	34.08	32.29	33.63	73.60

There were no significant associations between error tendency and age groups for the estimation of throwing, χ^2 (4)=.90, *p*=.93, and kicking, χ^2 (4)=5.29, *p*=.26.

Table 15 - Percentages of error tendency in the estimation of kicking, divided by gender and age groups

Error Tendency (%)	Gender		Age groups (years)			Overall sample
	Boys (*n*=160)	Girls (n=143)	6.48-8.01 (*n*= 102)	8.02-9.22 (*n*=101)	9.24-10.93 (*n*= 100)	(*n*= 303)
Underestimation	52.94	47.06	47.06	29.41	23.53	11.22
Accurate	50.65	49.35	25.97	38.96	35.05	25.41
Overestimation	53.65	46.35	34.38	31.77	33.85	63.37

3.7. Discussion

Children overestimated their real performance in both manipulative skills (throwing: 73.60%; kicking: 63.37%). Most children predicted they would achieve greater distances in both tasks than they really could, showing a discrepancy between estimated and actual ball abilities. However, the results of this study indicate that the accuracy for throwing and kicking is independent of the gender of the children. The differences between genders that were apparent in AE, with girls displayed less error (in meters) than boys for both skills, disappeared when their estimation was expressed in percentage (APE) for the throwing.

With increasing age, children tend to underestimate their ability for kicking, however this result did not reach significance. Younger children (group 1), showed significantly greater APE for the throwing, when compared with older children (group 3). These results are in good agreement with the findings of Plumert (1995), and Plumert and Schwebel (1997) that older children are more accurate than younger children, although these authors used different tasks and variables to reach these results. For the kicking, unexpectedly, the intermediate age group (group 2) exhibited greater APE values than groups 1 and 3. One possible explication is that young children were more cautious on their estimations, to make sure they did not fail. The intermediate age group might have not used this strategy. In other words, the intermediate age group seems to have an excessive self-confidence in their skills. Older children may have had more opportunities to judge their FMS in a variety of activities and settings, that is, they are more experienced. This trend has also been found in Study 1, for the SLJ.

We have additionally found that older children have a better performance on the throwing and kicking tasks, than younger children, also in agreement with literature (*e.g*., Butterfield, Angell, & Mason, 2012).

The results of this study also indicated that throwing and kicking are positively but weakly associated with chronological age. When this relationship was examined in terms of group-ages, it was found that older children were significantly better in both tasks when compared with the younger group.

Regarding the gender, boy's performance exceeded that of girls in the throwing and kicking tasks, confirming the gender differences reported in the literature for the ball skills (*e.g.,* Barnett, Morgan, van Beurden, & Beard, 2008; Barnett, van Beurden, Morgan, Brooks, & Beard, 2008; Wrotniak et al., 2006).

It is known that gender is highly discriminative when it comes to ball skills. This is believed to be related to the children's experience and gender role socialization, since the differences in the physical capabilities of boys and girls are, in average, insignificant (Thomas, & French, 1985). The gender differences obtained in the manipulative tasks of this study may thus be explained by the different reinforcement children in this age receive to participate in activities using these skills. Thomas and French's meta-analysis found that, for throwing accuracy, gender differences were nor related to age, that is, boys and girls had similar performances, and these did not change as they got older. The same study reported a large effect sizes at all ages (preschool: d=1.5; adolescence: d= 3.0) but increasing with age for the throwing in distance and velocity.

We have also found that real throwing and kicking competences are positively associated with children's estimated competences. This is in agreement with Barnett and collaborators (2014), and Liong et al. (2015) where, and similarly to our study, the perceived competence items where shown to be direct reflection of the motor competence. Additionally, we have found a significant correlation between estimated and real skills for both genders. Liong and colleagues (2015) found that boys' perception was associated with their actual OC competence (r=.26) but, contrarily to our results, the association was not significant for girls. Barnett and co-authors (2014) found that actual OC competence (six perceived skills) was associated with perceived competence (β=.11, *p*=.027), and this relationship did not differ with gender. They also found that neither actual nor perceived OC competence were associated with physical activity. In our study, and for the throwing performance, both predictor variables made a significant contribution to predicting the outcome; the more so the estimation than the chronological age. Nevertheless, for the kicking performance, the only significant contribution to the prediction model came from the estimation.

The study by Liong and colleagues (2015) found that boys' perceived OC scores significantly predicted the actual competence (six perceived and real OC skills) (β=.69), accounting for 27.2% of the adjusted variance. In this work we have found a very similar value of variance for the throwing competence of boys, and for the kicking competence of both genders (about 30%).

As in Study 1, the results show that children exhibit a tendency to overestimate their abilities.

Study 3

Differences Between Estimation And Real Performance In School-age Children: Maximum Walking Backwards on a Balance Beam

The purpose of this third study was to investigate the ability to accurately estimate the Walking Backwards (WB) skill. To our knowledge, no studies have addressed fundamental stability skills in childhood, namely dynamic balance skills. Dynamic balance involves the control of the body as it moves. In this study we have specifically looked at the WB on a balance beam.

Stability represents the most essential of the three categories of movement, that is, there is a component of stability in each locomotor and manipulative movements, and it requires considerable coordination and kinesthetic sensivity to where the body is in space. Stability comprises axial (*e.g.,* bending, twisting) and springing (*e.g.,* trampoline skills) movements, upright (*e.g*., balance-beam skills, balance-block skills, balance-board skills) and inverted (*e.g.,* headstand and handstand skills) supports, all of which involve static or dynamic movement situations (Gallahue, & Cleland-Donnelly, 2007). According to Malina (2004), balance is very important in the refinement of walking and the development of further movement skills. According to Thomas and French's meta-analysis (1985), and concerning balance, there are no balance differences during childhood, however, after puberty boys shown better performance. Other studies showed that girls perform best in test of balance during childhood (*e.g.,* Raudsepp, & Paasuke, 1995).

While the relation between estimation and real performance has been investigated for locomotor (Liong, Ridgers, & Barnett, 2015), and object control skills (Barnett et al., 2014; Liong et al., 2015), this relation on stability remains to be explored. Taking into account studies made on other abilities, we predict a greater overestimation tendency in children, particularly in boys. This would be consistent with their greater perception of physical competence, as has been reported by studies that addressed perceived competence as a psychological construct.

3.8. Methods

Participants

The same children as in Studies 1 and 2.

Measures and Procedure

Participants performed a stability task in which they walked backwards along a balance beam (6 cm wide, 3 cm high, and 3 m long) without stepping off the beam. The children completed the estimation judgment task before the action performance task. Once the participants indicated they understood the procedure, the estimation judgment was collected. The observer asked the children to estimate the farthest distance they could walk backwards before performing the task. The observer slowly unraveled a measuring tape until the child told her to stop. This measurement corresponded to child's estimated maximum WB. The child was allowed to fine-tune the measurement until she/he was satisfied. The estimation task was performed from the starting position in the standing front upright posture, after which the child turned and performed the real action backwards. The task was performed twice and the best score (measured in cm) was used for analysis (see Fig. 5).

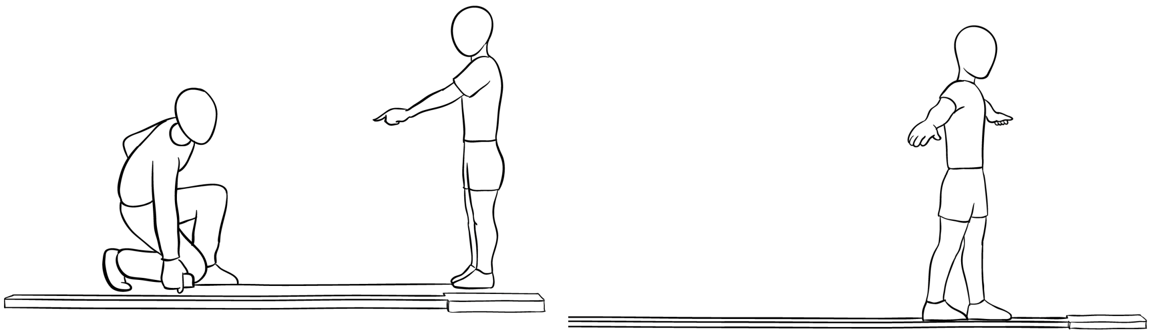

Figure 5 - Estimation (left) and performance (right) of the walking backwards balance task

Data collection and analysis

As in the other two studies, children's accuracy was determined on the basis of absolute percent error (|1- estimation/real performance| × 100), absolute error (|real performance – estimation|) and error tendency (*i.e.,* frequency of overestimation, accuracy, and underestimation bias).

As for the jumping task, a ±12 cm error was allowed for estimations to be considered accurate. This value was chosen by taking as *criteria* the average variability of the SLJ data (*SD*=25.42), and the children's foot size. Taking this into account, an overestimation occurred when the estimation was more than 12 cm above that of the real performance and an underestimation occurred when the estimation was less than 12 cm from the real performance. Independent samples *t*-tests were used to compare differences in the real performance, estimation, and in the error variables (AE and APE) between genders. Pearson's chi-square tests were used to determine differences in error tendency according to gender and age groups. ANOVAs were used to examine the effect of age on WB, APE, and AE. Pearson correlations were used to examine relationships between the variables (real performance, estimation, and chronological age). Chronological age and estimation of WB (independent or predictor variables) were used on a standard regression analysis to predict real WB performance (dependent or outcome variable). The level of significance for statistical analyses was set at $p<.05$. Data analyses were conducted using SPSS (version 21).

3.9. Results

Walking Backwards: estimation and real performance

Although girls (*M*=201.91, *SD*=107.99, range 30-300 cm) performed, on average, better than boys (*M*=195.64, *SD*=102.42, range 25-300 cm), this was not statistically significant (*t(301)*=-.52, *p*=.60). A main effect of age was found ($F(2,300)=15.17$, $p<.001$, $\eta^2_p= .09$). *Post hoc* analysis showed a statistically significant difference between the oldest age group (group 3) and the two younger age groups (group 1: *p*<.001; group 2: *p*=.004).

On average, boys estimated more (*M*=240.56, *SD*=67.83) than girls (*M*=223.74, *SD*=76.29). This difference was significant (*t*(301)=2.03, *p*=.04) (see Table 18).

There was a significant but weakly association between chronological age and maximum WB (*r*=.29, *p*<.001). After separating by gender, there was a significant association between boys' chronological age and real WB (*r*=.31, *p*<.001), and girls' chronological age and real WB (*r*=.28, *p*=.001).

Children's estimations and real performances were positively but weakly correlated (*r*=.20, *p*<.001). When dividing by gender, there was a significant but weak association between boys' estimated and real WB (*r*=.25, *p*=.002), and girls' estimated and real WB (*r*=.17, *p*=.04).

Children's estimations and chronological age were positively but weakly correlated (*r*=.19, *p*=.001). After separating by gender, there was a significant association between boys' estimated WB and chronological age (*r*=.28, *p*<.001); however, there was no significant association between girls' estimated WB and chronological age (*r*=.12, *p*=.16).

All correlations, except that relating estimation and chronological age for girls, were statistically significant.

Results of the standard multiple regression analyses were as follows:

Boys

A significant regression equation was found ($F(2,157)=10.91$, $p<.001$), with an R^2 of .122. The weighted combination of the predictor variables explained only 12.2% of the variance of real performance. Both estimation of WB and chronological age, were significant predictors of real WB. The Beta values for chronological age and estimation are .256, indicating that both variables have a comparable degree of importance in the prediction model (see Table 16).

Table 16 - Standard regression results for boys' walking backwards

Model	*b*	*SE-b*	Beta	Pearson *r*	*p*
Constant	-60.855	57.935			
Estimation of WB	.266	.118	.256	.25**	.025
Chronological age	22.438	6.823	.256	.31**	.001

Note: the dependent variable was WB real performance

R^2=.122, Adjusted R^2=.111

*p<.05, **p<.01

Girls

A significant regression equation was found ($F(2,140)=7.59$, $p=.001$), with an R^2 of .098, that is, the proportion of the variance explained by the model is just 9.8%. In this case only the chronological age was a significant predictor of real WB (see Table 17).

Table 17 - Standard regression results for girls' walking backwards

Model	*b*	*SE-b*	Beta	Pearson *r*	*p*
Constant	-55.185	67.836			
Estimation of WB	.200	.114	.141	.17*	.082
Chronological age	22.457	7.525	.263	.28**	.001

Note: the dependent variable was WB real performance
$R^2=.098$, Adjusted $R^2=.085$
*$p<.05$, **$p<.01$

Magnitude of error: Absolute Error and Absolute Percent Error

The descriptive statistics for estimation of WB, WB, AE, and APE, divided by gender and age groups, are depicted in Table 18. Concerning the AE and APE, boys and girls were not significantly different: AE: $t(301)=-.66$, $p=.50$, and APE: $t(301)=-.16$, $p=.88$.

Table 18 - Descriptive statistics (mean and *SD*) divided by gender and age groups, for estimation of walking backwards (in cm), walking backwards (in cm), absolute error (in cm) and absolute percent error (in %)

	Gender		Age groups (years)			Overall sample
Variable	Boys (*n*=160) *M* (*SD*)	Girls (n=143) *M* (*SD*)	6.48-8.01 (*n*= 102) *M* (*SD*)	8.02-9.22 (*n*=101) *M* (*SD*)	9.24-10.93 (*n*= 100) *M* (*SD*)	(*n*=303)
EWB (cm)	240.56 (67.83)	223.74 (76.29)	220.42 (76.05)	224.13 (73.98)	253.64 (62.07)	232.62 (72.31)
WB (cm)	195.64 (102.42)	201.91 (107.99)	162.43 (100.17)	194.27 (106.18)	239.86 (94.30)	198.59 (104.96)
AE (cm)	87.24 (77.55)	93.34 (79.67)	57.99 (116.80)	29.86 (113.66)	17.78 (110.00)	34.02 (114.66)
APE (%)	99.55 (136.16)	102.00 (143.66)	130.98 (148.96)	92.29 (117.32)	78.41 (146.03)	100.73 (139.52)

EWB – Estimation of Walking Backwards; WB – Walking Backwards; AE – Absolute error; APE –Absolute percent error

Regarding the AE (*i.e.*, |real-estimation|, in cm), ANOVAs revealed a significant effect of age ($F(2,300)= 3.93$, $p=.02$, $\eta^2_p=.03$). *Post hoc* analysis showed a statistically significant difference between the older and the youngest age groups ($p=.02$). Mean values for APE suggested a decrease in judgment error (expressed as %) with age. A main effect of age was found: APE, $F(2,300)=3.94$, $p=.02$, $\eta^2_p=.03$. *Post hoc* analysis showed a statistically significant difference between the oldest age group (group 3) and the youngest one (group 1) (p=.02).

Error Tendency

Table 19 depicts the error tendency for WB task, by gender and age groups. It can be seen that children have a tendency to overestimate their WB performance (45.21%).

Table 19 - Percentages of error tendency in the estimation of walking backward, presented as gender and age groups

Error Tendency (%)	Gender		Age groups (years)			Overall sample
	Boys (n=160)	Girls (n=143)	6.48-8.01 (n= 102)	8.02-9.22 (n=101)	9.24-10.93 (n= 100)	(n= 303)
Underestimation	47.73	52.27	31.82	31.82	36.36	29.05
Accurate	53.85	46.15	16.67	30.77	52.56	25.74
Overestimation	55.47	44.53	44.53	35.77	19.71	45.21

About 29.05% of the children tend to underestimate and 25.74% are able to accurately estimate their WB. A scatter plot of children's estimation and real WB is presented in Figure 6.

Boys have more tendency to overestimate their WB skills, whereas girls tend to underestimate, however this difference was not significant (χ^2 (2)=1.034, p=.52). There was a significant association between error tendency and age groups (χ^2 (4)=28.72, $p<.001$). The results show that there is gradual decrease in the overestimation bias with aging, with the older children being more accurate than younger children. When comparing the older and the youngest age group this difference becomes statistically significant both for the overestimation and the accuracy.

3.10. Discussion

Similar to the results obtained in the previous studies, children demonstrated an overestimation bias of the distance, which they thought they could walk backwards on a balance beam (45.21% overestimation). It should be noted, however, that the task was performed in a risk-free environment, which may not be generalizable to potentially risky real-life situations. The fear of injuries was not present during the task since this was conducted on a regular ground, and the balance beam was only 3 cm high.

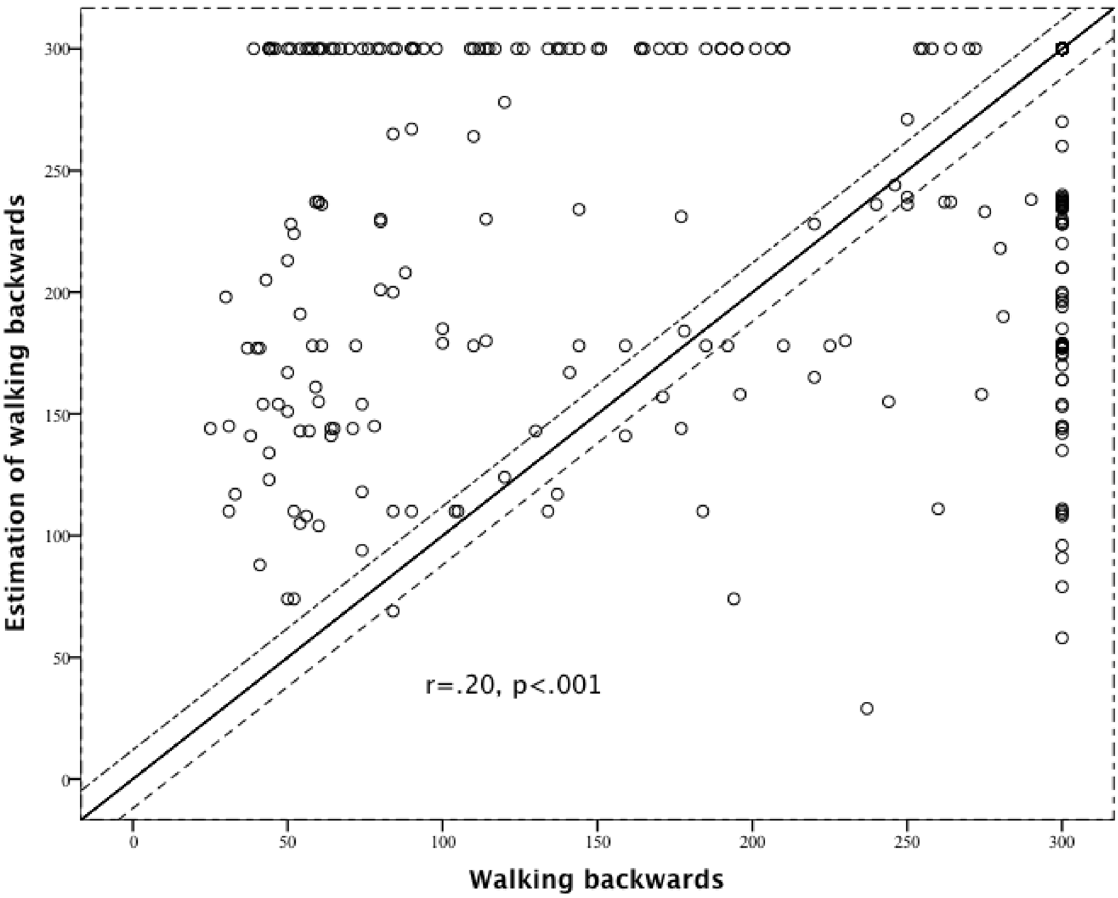

Figure 6 - Scatter plot of children's estimation and real performance for walking backwards (in cm) on a balance beam. The continuous line represents perfect agreement between estimation and real performance (*n*=69 children estimated and performed the whole beam). The dashed lines indicate the interval within which the task is considered accurate (±12 cm). Estimations above the top dashed line were considered overestimations. Estimations below the bottom dashed line were considered underestimations

When compared with older children, young children displayed significantly more error, both expressed as percentage, and in cm. With increasing age, older children tend to be significantly more accurate, and to overestimate less, which is in agreement with other studies that showed older children were more accurate than younger children in other tasks (*e.g.*, Plumert, 1995). Boys made smaller error (AE and APE) than girls, however this difference did not reach significance.

Our results suggest that older children (group 3) were significantly more able to perform WB more proficiency than younger children (groups 1 and 2). However, no gender differences for this FMS were present. For the balance, it has been shown that gender differences are not present during childhood (*d*=0) but increase to a moderate level, favoring boys at adolescence (*d*=.1). This increase is more likely to reflect environmental factors rather than biological factors related to puberty (Thomas, & French, 1985).

In this study we have found that children's estimated and real WB skills were significantly associated. Although real performance was correlated with estimation and chronological age for both genders, our findings indicated that: (i) for girls only chronological age significantly predicted real WB, explaining only about 10% of the adjusted variance and leaving about 90% of the variability to be accounted for by other variables; (ii) for boys, both predictors made a significant contribution to the model, showing the same weight (β=.256), but only 12.2% of the variability in the outcome was accounted for, using these predictors. It is difficult to compare these findings to other studies because, and to our knowledge, no studies have examined whether children's estimated and real stability skills are associated with each other and also with other variables.

The findings of this study, again demonstrate that children overestimate a FMS, in this case, a fundamental stability skill, and no gender differences were found.

3.11. General Discussion

This investigation analyzed the perception of *affordances* across a range of FMS, that is, the ability to recognize whether an action could be performed. The results of this three studies showed that children consistently overestimate their FMS, supporting the hypothesis that children tend to overestimate their action capabilities.

Previous research has suggested that children overestimate their action capabilities for different FMS (*e.g.*, Gabbard, Caçola, & Cordova, 2008; Plumert, 1995). As suggested by previous authors (Gabbard, Caçola, & Cordova, 2009), this overestimation was investigated in specific tasks, the SLJ, the throwing, the kicking, and the WB, which are fundamental movements that integrate the repertoire of children's skills.

The mastery in FMS is a requisite for the acquisition of specialized motor skills, and a positive perception of motor competence has important consequences for children's overall development. Even though a positive perception of motor competence might be positive, it may also have implications for children's safety, and concomitantly put them at risk for serious accidental injuries (Plumert, 1995; Plumert, & Schwebel, 1997). For example, children might try to cross impossible wide gaps, being more prone to falls, if they think they can step or jump farther than they really can.

Plumert (1995) suggested two factors that may play a role in the overestimation of abilities. The first concerns the attractiveness of the goal. The second may be related to the way the tasks are conducted, where the fact that there is no bodily penalty may lead to an overestimation of the abilities. In other words, when errors have aversive consequences, children will probably be more careful.

Although research with children has used challenging tasks, such as locomotion over slopes (Adolph, Eppler, & Gibson, 1993) or crossing gaps (Plumert, Kearney, & Cremer, 2004), most investigations, including this one, are performed in safe environments, and so the overestimation of children may have been potentiated by the environment that was provided to them. Therefore, the results should be interpreted with caution.

Whereas 45.21% of the children overestimate the WB, and 56.11% the jumping, 63.37% and 73.60% of the children overestimate their kicking, and throwing abilities, respectively. One possible reason for this discrepancy is the familiarity of the skill. For the less common skill, the WB, the percentage of overestimation was lower, when compared with the manipulative skills. There was also a higher percentage of underestimation (29.05%) in WB. The unfamiliarity of the task may have contributed for a more conservative judgment, when compared to the other actions. In addition, throwing and kicking a ball into a soccer goal do not involve risk.

In the theoretical framework of the ecological psychology approach, the gender differences in estimation of physical abilities have not yet been documented. Instead, the focus of the available studies is on perceived motor competence as a psychological construct, with boys demonstrating higher perceived motor competence scores than girls (Harter, 1982; Granleese, Trew, & Turner, 1988; Raudsepp, & Liblik, 2002). In addition, it has been found that boys' perception was associated with their real object control ability (Liong, et al., 2015).

In Study 1 we found evidences that girls are more likely to underestimate their SLJ capability than boys, whereas the boys tend to overestimate their capability more frequently than girls. For the other studies, no differences in the ET were found between genders. Boys are known to be slightly more active, to obtain more pleasure from high-intensity stimuli, and to engage in active rough-and-tumble, whereas girls display a stronger ability to manage, and regulate their attention, and inhibit their impulses (Else-Quest, Hyde, Goldsmith, & Hulle, 2006). According to previous studies (Plumert, & Schwebel, 1997; Schwebel, & Plumert, 1999), impulsive, and highly active children are more likely to overestimate their abilities. Although quite speculative, one possible explanation for the results of this study is perhaps that the temperament of children is influenced by gender. That is, gender differences in temperament such as attention, impulsivity, and inhibitory control, amongst other factors, may play a role in the accuracy of the child's judgments about its own physical abilities. The fact that girls showed a more cautious estimation of their real ability might reduce the occurrence of negative consequences of an overestimation but, on the other hand, it is also possible that they do not refine knowledge of the limits of their own action capabilities. Schwebel and Plumert (1999) have highlighted both the social, and the developmental consequences of children's underestimation of action capabilities. In their opinion, children who underestimate their physical abilities are more likely to social withdrawal, and physical inactivity.

During this work we have also focused on how age influences estimation, and accuracy. Previous studies showed that with increasing age, children show a tendency to become more accurate in the judgment of their competences (*e.g.,* Gabbard, Cordova, & Ammar, 2007; Klevberg, & Anderson, 2002; Plumert, 1995). The explanation for increasing accuracy with age is related to the developmental differences between groups, and is supported by previous studies (*e.g.*, Grechkin, Chihak, Cremer, Kearney, & Plumert, 2013; Plumert, 1995).

The literature on the field of motor development indicates that children have mastered the fundamental movement patterns by the age of 6-7 years (Gallahue, & Ozmun, 2006). In this work we report that girls performed worst than boys in jumping, throwing, and kicking tasks. On the other hand, older children exceeded the younger children significantly on all four skills. These differences could be explained by the interaction of biological, and environmental influences, since gender differences in the biological characteristics, such as height, weight, and muscle mass are minimal during childhood (Haywood, & Getchell, 2009). On the other hand, boys are more physically active than girls (*e.g.,* Finn, Johannse, & Specker, 2002; Pate, Pfeiffer, Trost, Ziegler, & Dowda, 2004), and are more engaged in opportunities, and experiences that refine their motor skills competence. Parental influences, and support (Gustafson, & Rhodes, 2006), and encouragement to practice by both peers and teachers, seem to underline the gender appropriate behavior, and most gender differences in motor competence prior to puberty are mostly socially induced (Thomas, & French, 1985). This suggests that environmental factors are more likely to explain gender differences in motor performance since the physical characteristics between boys and girls are similar prior to puberty.

Overall, our findings suggest that children between the ages of 6 to 10 years systematically overestimated their skills, and that the growth-related tendency to became more accurate is not consistently present across the four FMS analyzed, namely for the jumping, and kicking.

3.12. Conclusions

The presented studies reveal that children's real and estimated competences for the assessed fundamental movement skills are associated, and that children overestimate their competences. Interestingly, we have found that boys significantly estimated more than girls. The overestimating tendency is present during childhood, a stage where children improve the quality of their performance, and accomplish more complex movement sequences required for specific sports, and games (Malina, 2004). Higher perceived competence is related with motor skill proficiency, and increased levels of physical activity (Stodden et al., 2008). The overestimation of children's capabilities may have a positive effect on engaging in movement activities, sports, and play that improve motor proficiency, but can also result in negative effects if children place themselves at risk of unintended injury.

The results of this investigation highlight the importance of giving children opportunities to practice, and estimate their motor proficiency. A more accurate perception of children's abilities will probably prevent, and reduce unintentional injuries, which might occur during their participation in sports or other activities, such as playing at home or in playgrounds.

3.13. References

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CHAPTER 4

STUDY 4

IS ESTIMATED MOTOR COMPETENCE IN CHILDREN ADJUSTED TO THEIR LEVEL OF MOTOR COORDINATION?

STUDY 4

IS ESTIMATED MOTOR COMPETENCE IN CHILDREN ADJUSTED TO THEIR LEVEL OF MOTOR COORDINATION?

Abstract

An inaccurate perception of motor competence might compromise the engagement of children in physical activities, and might be a problem in terms of child safety. The influence of children's motor coordination level on the accuracy of their perceptual judgment needs to be investigated using context specific tasks. One hundred fifty-three children (8.74 years ±1.17) were selected from a total of 303 participants. Children's motor coordination (Köperkoordinationstest für Kinder, KTK), motor performance, and estimation of competence for jumping, kicking, throwing, and Walking Backwards (WB) on a balance task, were assessed. The initial sample was ranked according to their coordination scores on the KTK battery. The 75 children with the highest score comprised the group with the Highest Motor Coordination (HMC), and the 78 children with the lowest scores, the Lowest Motor Coordination (LMC) group. Magnitude of error (absolute percent error) was significantly greater for the LMC group on WB, and throwing tasks. There was a tendency for LMC, and HMC children to overestimate their capabilities at all tasks, except for the balance task, where HMC children had a greater frequency of accurate estimations. The magnitude of error, and the error tendency exhibited by the LMC and HMC groups indicate that estimated competence errors in some tasks are influenced by the child's level of coordination.

Keywords:

Motor coordination, motor competence, estimation, children, fundamental movement skills

4.1. Introduction

Motor competence represents the person's ability to be proficient (*i.e.*, skillful) on several motor acts or skills (Fransen et al., 2014). According to Gallahue and Cleland-Donnelly (2007), motor competence develops rapidly if children have opportunities for practice, positive encouragement, and quality individualized instruction. In order to achieve proficiency in complex motor skills, such as specialized movements employed in sport activities, children must master in different Fundamental Movement Skills (FMS). These movements are commonly categorized into locomotor (*e.g.*, jumping, running, hopping), manipulative (*e.g.*, throwing, kicking, catching), and stability (*e.g.*, balancing, twisting) skills, and typically follow a developmental sequence from an immature to a more mature stage (Gallahue, & Ozmun, 2006). Children do not "naturally" attain proficient levels of FMS. The developmental sequence for FMS during childhood is not only dependent upon biological and neuromuscular maturation, but it is also influenced by the interaction of environmental factors, opportunities and experiences, encouragement, and instruction (Gallahue, & Ozmun, 2006). Mastering in fundamental motor skills and achieving higher levels of motor competence is not only important for an adequate participation in organized physical activities but also for the adoption of active lifestyles.

Stodden et al. (2008) proposed a conceptual model to explain the reciprocal and developmentally dynamic relationship between motor competence and physical activity. According to this model, motor competence drives physical activity levels, because higher levels of motor skill development during middle and late childhood will offer greater opportunities for children to engage in different physical activities and sports. However, some mediating variables, such as perceived motor competence and health-related physical fitness, might interact with the dynamic relationship between motor competence and physical activity, leading to positive or negative spirals of engagement. For example, if low-skilled children perceive themselves as having little motor competence, they will probably choose not to engage in physical activity and ultimately will be at greater risk of being obese and sedentary during adolescence and adulthood.

Perceived motor competence has been studied as a psychological construct (Harter, 1978, 1982) and different scales, based on self-reported measures, have been used to assess the perceived physical competence of children and adolescents (*e.g.,* Fox, & Corbin, 1989; Harter, 1982; Harter, & Pike, 1984; Marsh, 1996; Pérez, & Sanz, 2005; Whitehead, 1995). These measures indicate that children under the age of 8 often relate competence to effort and persistence, overestimating frequently their actual level of motor competence (*e.g.*, Harter, & Pike, 1984), even if they often have low motor competence, which might be positive for their engagement in physical activities according to Stodden's model. However, a study by Gabbard and co-authors (Gabbard, Caçola, & Cordova, 2009) has suggested that context-specific tasks, instead of self-reported measures, should be used to determine children's perception of motor competence. In fact, some recent research examining the association between real and perceived motor competence started to use the same tasks to evaluate perceived skills and real skill ability (Barnett, Ridgers, & Salmon, 2014; Barnett, Ridgers, Zask, & Salmon, 2015; Liong, Ridgers, & Barnett, 2015). However, the measures in these studies were based on self-report items in which children discriminated between good and poor skill performance, reporting how good they think they would be in a certain motor skill, but not giving an accurate estimation of their capabilities. Studies with more discriminative tasks are needed to better understand the association between real and estimated motor competence.

There is compelling evidence that children make inaccurate estimations of their competences. The lack of accuracy reflects a general tendency to overestimate action capabilities (*e.g*., Plumert, 1995). The overestimation of motor capabilities, that has been reported to occur in different studies, might be good to stimulate attempts, effort and persistence, but it might also pose a problem in terms of child safety. For example, children might risk jumping impossible gaps if they are confident that they can jump farther than they actually can. The outcome of that behavior will probably be an injury.

The relation between injury and motor competence presents some inconsistent findings (see Schwebel, Binder, Sales, & Plumert, 2003), with at least one study indicating that children that suffer more accidents have poorer motor skills (Angle, 1975), some indicating the opposite (Langley, Silva, & Williams, 1980; Manheimer, & Mellinger, 1967) and others pointing for no relation between motor skills and accident proneness (Schwebel, et al., 2003). Issues relating to i) the measurements of the constructs (*i.e.,* injuries and motor ability), ii) the different rates of exposure to risk between high and low coordinated children, or iii) the temperamental characteristics of the children, have been advanced to explain the inconsistent findings and the lack of correlation between injury and motor competence. It has been suggested (Schwebel, et al., 2003) that a combination of temperamental characteristics, overestimation of motor capabilities, and motor competence may play a role in injury risk. The overestimation of motor capabilities has been reported to occur more frequently in younger ages (Harter, 1982; Harter, & Pike, 1984) and in boys (Carroll, & Loumidis, 2001; Harter, 1982; Raudsepp, & Liblik, 2002; Robinson, 2011; Rudisill, Mahar, & Meaney, 1993) but, to our knowledge, the influence of the motor coordination level of the child on the accuracy of his or her perceptual judgment has not yet been thoroughly investigated.

In the present study, we investigated the relationship between estimation and real motor performance in children with different motor coordination levels using different context specific tasks. It was hypothesized that less coordinated children would have lower estimations and performances in different skills (locomotor, manipulative, and stability) than their peers with higher motor coordination; and that children with lower coordination would present a greater overestimation tendency and be less accurate in estimating their actual performance.

4.2. Methods

Participants

One hundred and fifty three children between the ages of 6.48 and 10.93 years participated in the study. None of the children presented developmental difficulties or learning disabilities, and all attended age-appropriate classes. Written informed consent was obtained from the parents and verbal agreement from the children. The initial sample (n=303) was ranked according to their scores in the Köperkoordinationstest für Kinder (KTK) (Kiphard, & Schilling, 1974) and divided in quartiles. The lower quartile (n=78; *M*=8.65 years; *SD*=1.10) and the upper quartile (n=75, *M*=8.65 years, *SD*=1.26) comprised the final sample, representing the groups with the Lowest Motor Coordination (LMC) level, and the Highest Motor Coordination (HMC) level, respectively.

Measures and Procedures

Each child was assessed for motor coordination (KTK), real performance and estimation of maximum capability in the several motor tasks: Standing Long Jump (SLJ), throwing and kicking, and Walking Backwards (WB) on a balance beam.

Motor Coordination

Motor coordination was determined by the KTK test, which is a product-oriented battery for children between 5 to 14 years (Kiphard, & Schilling, 1974). The battery assesses gross body control and coordination, namely general dynamic balance skill (Cools, Martelaer, Samaey, & Andries, 2009). The KTK was selected for the assessment of motor coordination because it is a commonly used, highly reliable and valid instrument, with a test–retest reliability coefficient for the raw score on the total test of .97 (Kiphard, & Schilling, 1974), and is often used in motor coordination research in Portugal (Lopes, Rodrigues, Maia, & Malina, 2011; Lopes, Stodden, Bianchi, Maia, & Rodrigues, 2012; Luz, Rodrigues, & Cordovil, 2014). KTK consists of four interdependent tasks: i) balancing backwards along three balance beams of decreasing width: 6, 4.5 and 3 cm; ii) hopping on one leg over an obstacle, which increases in height after successful attempts; iii) jumping laterally as fast as possible for 15''; and iv) moving sideways as fast as possible for 20'' using two wooden platforms (25 cm x 25 cm x 2 cm). These tasks aim to evaluate children's general dynamic body coordination and body control (dynamic balance) (Cools et al., 2009). Each child was assessed individually according to the test guidelines and the overall motor quotient (MQ) was determined taking into account the gender and age factors. The MQ categories are: 'not possible' (MQ <56), 'severe motor disorder' (MQ 56–70), 'moderate motor disorder' (MQ 71–85), 'normal' (MQ 86–115), 'good' (MQ 116–130) and 'high' (MQ 131–145).

Standing Long Jump

The SLJ performance was measured following standard procedures (Chung, Chong, & Chung, 2013; Gontarev, Zivkovic, Velickovska, & Naumovski, 2014). The child was instructed to jump as far as possible from a standing start with feet slightly apart. The test was performed twice and the best of the 2 attempts (measured in cm) was used for analysis. Before performing the SLJ, the child was asked to estimate his/her maximum jumping distance. During this estimation, the participant stood behind a line, while the evaluator starting at the feet of the child, slowly and steadily unraveled a measuring tape until the child told her to stop, indicating the maximum estimated distance of jump (see Fig. 7). The child was allowed to make fine adjustments after the order to stop if he/she found it necessary. The task was conducted in a uniform floor with no marks that could help the child to memorize the estimated location.

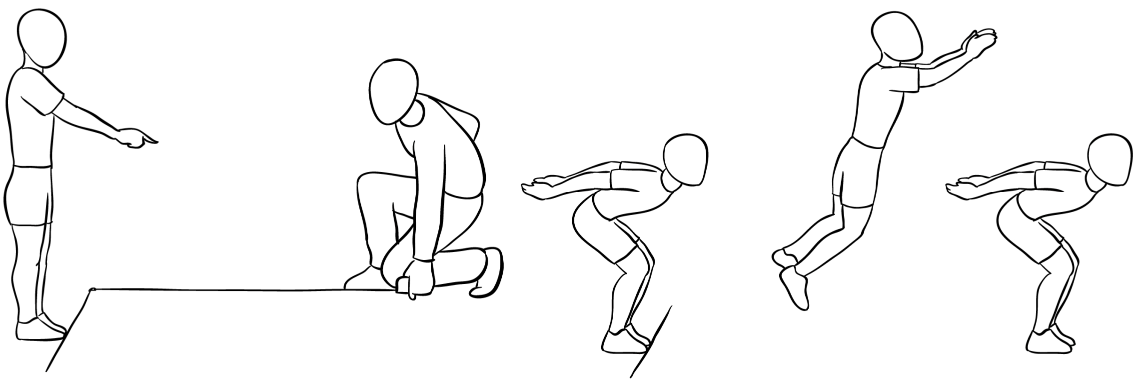

Figure 7 - Estimation (left) and performance (right) of the standing long jump task

Throwing and Kicking

For the throwing condition, a mini soccer goal (120 cm × 80 cm) was placed 1 m above the floor on a table, and a softball was used. For the kicking condition, the mini soccer goal was placed on the floor, and a size 4 soccer ball was used. The floor was marked every 2 m, from 2 m to 20 m away from goal (see Fig. 8). In both tasks, the child stood upright in front of the goal and behind the 20 m line. From this position, the child was asked to go to the mark that he/she estimated to be the maximum distance to successfully throw/kick the ball into to the mini soccer goal. This distance was registered as the child's estimation. After that, the evaluator asked the child to throw/ kick the ball into the target. If the child succeeded, he/she was asked to throw/kick from a farther line. This procedure was repeated until the child failed the target. When the child failed (in any throw/kick position), he/she was asked to throw/kick from a closer line. This procedure was repeated until the child succeeded. The final successful position was the real distance recorded.

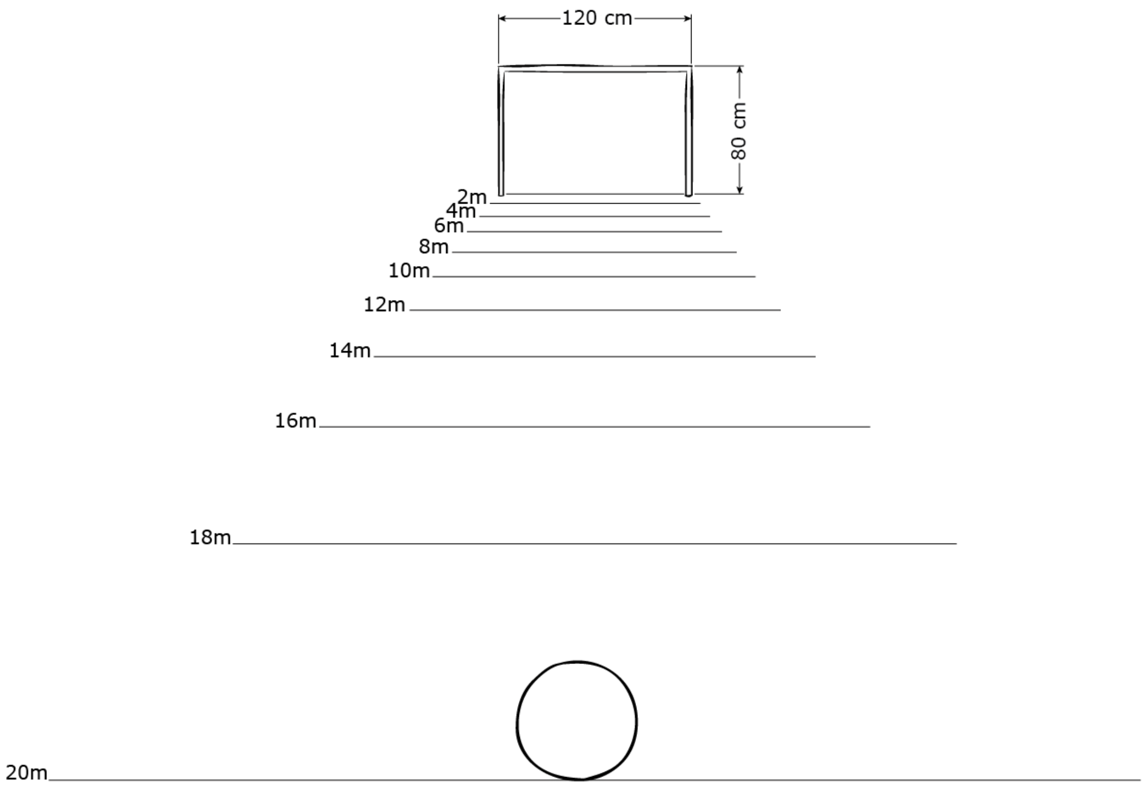

Figure 8 - Apparatus used for the estimation of the kicking task. The same marks and goal were used for the throwing task, but the goal was placed 1m above the floor, on one table

Walking Backwards on a balance beam

Participants also performed a balance task in which they walked backwards along a balance beam, 6 cm wide, 3 cm high, and 3 m long, without stepping off the beam. Children estimated how far they could walk backwards before performing the task. Once the participants indicated they understood the procedure, the estimation judgment was collected.

The observer asked the children to estimate the farthest distance they could walk backwards before performing the task. The observer slowly unraveled a measuring tape until the child told her to stop. This measurement corresponded to child's estimated maximum WB. The child was allowed to fine-tune the measurement until she/he was satisfied. The estimation task was performed from the starting position in the standing front upright posture, after which the child turned and performed the real action backwards. The task was performed twice and the best score (measured in cm) was used for analysis (see Fig. 9).

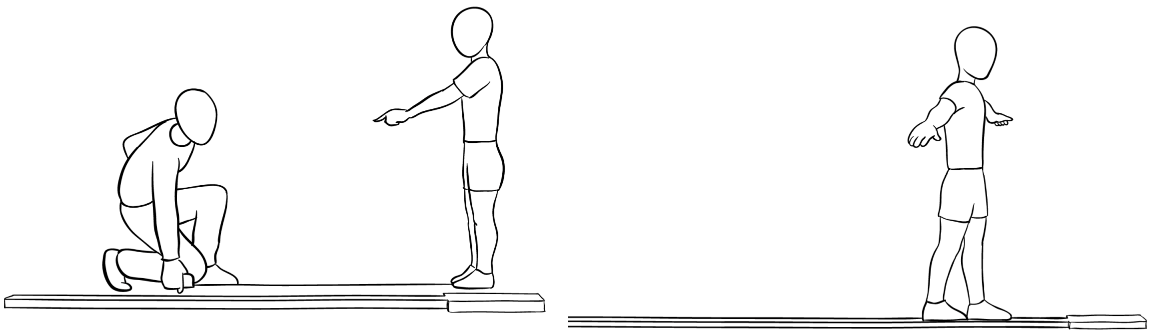

Figure 9 - Estimation (left) and performance (right) of the walking backwards balance task

Data collection and analysis

Absolute Error (AE), Absolute Percent Error (APE) and Error Tendency (ET) of the jumping, kicking, throwing, and WB tasks were analyzed. These measures were calculated according to Cordovil and Barreiros (*cf.*, Cordovil, & Barreiros, 2011). Absolute error is defined as the difference between the real performance and the estimation (|real performance – estimation|). Absolute error indicates the discrepancy in centimeters (jumping and walking backwards) or in meters (throwing and kicking) between estimation and real motor performance. Absolute percent error (|1- estimation/real performance| × 100) is the amount of judgment error expressed as percentage of the real performance. Absolute error and absolute percent error measure the error magnitude but not the under- or overestimation bias. Error tendency (*i.e.*, frequency of overestimation, accuracy, and underestimation bias) indicates the direction of the error. For the jumping and WB tasks, a ±12 cm error was allowed for estimations to be considered accurate. This value was settled by taking the average variability of the SLJ data, and the children's foot size as *criteria*. Considering this, an overestimation occurred when the estimation was more than 12 cm above that of the real performance and an underestimation occurred when the estimation was less than 12 cm from the real performance. Pearson's chi-square tests were used to determine differences in error tendency between the LMC and HMC groups, and independent samples *t*-tests were used to compare differences in the motor performance and in the error accuracy variables between the two groups. Pearson's correlations were conducted to examine associations between children's estimations and their real motor performance, separated by level of motor coordination (LMC vs HMC). A simple linear regression, that treated the groups individually, was calculated for significant associations, to predict real competence based on estimation, that is, the degree to which estimation predicts the real motor performance. Thus, estimated competence was considered as the predictor variable (independent) and the outcome (dependent variable) as the real performance. The level of significance for statistical analyses was set at $p<.05$. Data analyses were conducted using SPSS (version 21).

4.3. Results

Results are summarized in Table 20, which presents the groups' mean estimation, mean real performance, mean absolute error (|real performance-estimation|), and mean absolute percent error (|1- estimation/real performance| × 100), for the motor tasks.

Motor coordination

According to the normative values of KTK test (Kiphard, & Schilling, 1974), the results for the lower quartile (*M*=100.41, *SD*=6.26, range 83-108) were indicative of "normal" coordination level and the upper quartile (*M*=132.16, *SD*=4.98, range 126-144) were at the "high" coordination level.

Estimation and real motor performance for fundamental movement skills

On average, children with HMC performed significantly better than their peers with LMC, for all motor tasks (see Table 20).

Children with HMC estimated ($t(151)=-3.78$, $p<.001$) and jumped ($t(151)=-5.13$, $p<.001$) farther than their peers with LMC. Significant differences between the two groups were found for the manipulative real tasks (throwing: $t(151)=-3.40$, $p=.001$; kicking: $t(151)=3.32$, $p=.001$). However, no significant differences were found for the estimation (throwing: $t(151)=-1.23$, $p=.22$; kicking: $t(151)=-1.89$, $p=.60$). In the balance task, significant groups differences were found for the estimation ($t(151)=-4.22$, $p<.001$), and for the real motor performance ($t(151)=-6.29$, $p<.001$).

Table 20 - Descriptive statistic (mean and *SD*) for the estimation, real performance, absolute error, and absolute percent error of the four motor tasks among children with the lowest motor coordination (LMC) and the highest motor coordination (HMC)

		Estimation (cm)	Real (cm)	Absolute Error (cm)	Absolute Percent Error (%)
Jumping	LMC	130.63 ± 37.19	114.08 ± 24.63	29.35± 28.76	28.92 ± 36.06
	HMC	151.49 ± 30.58	134.61 ± 24.91	27.89±25.37	22.89 ± 26.09
Throwing	LMC	7.03 ± 2.86	3.95 ± 2.01	3.38 ± 2.42	112.07 ±105.89
	HMC	7.65 ± 3.44	5.28 ±2.78	2.69 ±2.60	76.03 ± 91.75
Kicking	LMC	7.61 ± 3.49	5.38 ± 2.80	2.69 ±2.39	69.33 ± 74.72
	HMC	8.66 ± 3.37	7.17 ± 3.79	2.77 ± 2.57	54.8 ± 73.77
Walking backwards	LMC	208.79 ± 80.15	147.95 ± 103.90	113.74 ± 79.97	150.80 ± 169. 43
	HMC	256.03 ± 55.46	252.54 ± 83.06	60.49 ± 67. 98	48.88 ± 90.44

Table 21 depicts the studied correlations between children's estimations and children's real motor performance, separated by coordination level. Children's estimations were significantly, and weak to moderately associated with children's real motor performance, for all skills except for the WB.

Table 21 - Correlations between children's estimations and children's real motor performance, divided by coordination level

Children's estimation	Children's real motor performance							
	Jumping		Throwing		Kicking		Walking backwards	
	LMC	HMC	LMC	HMC	LMC	HMC	LMC	HMC
Jumping	.31**	.27*						
Throwing			.38**	.58**				
Kicking					.61**	.53**		
Walking Backwards							.09	.18

LMC - Lowest Motor Coordination group; HMC - Highest Motor Coordination group
* *p*<.05; ** *p*<.01

Results of the simple regression analyses are as follows:

For the LMC group:

(i) children's estimated SLJ significantly predicted real SLJ skill (*b*=.21, β=.31, *t*= 2.84, *p*=.006) but accounted only 9.6% of the adjusted variance (R^2=.096, *F*(1,76)=8.08, *p*=.006); ii) children's estimated throwing significantly predicted real throwing skill (*b*=.27, β=. 38, *t*= 3.57, *p*=.001), accounting for 14.4% of the adjusted variance (R^2=.144, *F*(1,76)=12.77, *p*=.001); iii) children's estimated kicking significantly predicted their real kicking skill (*b*=.49, β=.61, *t*=6.79, *p*<.001) and accounted 37.8% of the adjusted variance (R^2=.378, *F*(1,76)=46.102, *p*<.001).

For the HMC group:

i) children's estimated SLJ significantly predicted real SLJ skill (*b*=.22, β=.27, *t*=2.04, *p*=.02) but accounted only 7.3% of the adjusted variance (R^2=.073, *F*(1,73)=5.77, *p*=.02); ii) children's estimated throwing significantly predicted real throwing skill (*b*=.47, β=.58, *t*=6.14, *p*<.001) and accounted 34.1% of the adjusted variance (R^2=.341, *F*(1,73)=37.71, *p*<.001); iii) children's estimated kicking significantly predicted real kicking skill (*b*=.60, β=.53, *t*=5.39, *p*<.001) accounting for 28.5% of the adjusted variance (R^2=.285, *F*(1,73)=29.04, *p*<.001).

Magnitude of error: Absolute Error and Absolute Percent Error

Table 20 shows the means and standard deviation for AE and APE. Concerning AE, no significant group differences were found for jumping (*t*(151)=.33, *p*=.74), and for manipulative tasks (throwing: *t*(151)=1.70, *p*=.90; kicking: *t*(151)=-.20, *p*=.84). However, in the balance task, children with HMC had lower AE than children with LMC (*t*(151)=4.43, *p*<.001). Regarding APE, children with HMC were generally more accurate than their peers with LMC. The differences were significant for throwing (*t*(151)=2.25, *p*=.03), and for WB (*t*(118.57)=2.19, *p*<.001). No group differences were found for kicking (*t(151)*=1.21, *p*=.23) or jumping (*t(151)*=1.18, *p*=.24).

Error Tendency

Results concerning error tendency are depicted in Table 22. The results show a significant association between the ET for the estimation of WB, and coordination group (χ^2 (2)=28.34, *p*<.001). In fact, 42.67% of HMC children made accurate estimations in this task compared to only 11.54% of the LMC group.

Table 22 - Percentages of error tendency in the estimation of the motor tasks among children with the lowest motor coordination (LMC) and the highest motor coordination (HMC)

	Jumping		Throwing		Kicking		Walking backwards	
	LMC	HMC	LMC	HMC	LMC	HMC	LMC	HMC
Underestimation	19.23	13.33	3.85	5.33	7.69	13.33	23.08	32.00
Accurate	26.92	32.00	11.54	26.67	28.21	29.33	11.54	42.67
Overestimation	53.85	54.67	84.62	68.00	64.10	57.33	65.38	25.33

The tendency of most children in the LMC group was to overestimate their WB ability (65.38% overestimations), whereas children in the HMC group were more accurate

(42.67% accurate estimations). There was also a significant difference for the throwing task (χ^2 (2)=6.18, *p*=.04). The tendency of both groups in this task was for overestimation, which was greater in the LMC group (84.62% *vs*. 68%). The HMC group was slightly more accurate than the LMC group in the throwing task (26.67% *vs*. 11.54% of accurate estimations). There was no relationship between ET and the motor coordination group for the other motor tasks (kicking: χ^2 (2)=1.47, *p*=.48; jumping: χ^2 (2)=1.15, *p*=.56).

4.4. Discussion

Perceived motor competence has been suggested as a mediating variable for the engagement and persistence in different physical activities and sports, which are determinant for children's motor development (Harter, 1978, 1999; Stodden at al., 2008). However, to our knowledge, the relationship between motor coordination level and estimated motor competence has not been fully explored in the literature. This study investigated the relationship between estimation and real performance in children with different levels of motor coordination, that is, whether children's estimations of their performance, on a set of motor tasks, were related to their coordination levels (higher *vs* lower).

As expected, children with LMC performed significantly lower at all motor tasks (*i.e.*, stability, locomotor and manipulative tasks) than their peers with HMC. Several studies support these findings (*e.g.,* Asonitou, Koutsouki, Kourtessis, & Charitou, 2012; Haga, 2008; Hands, 2008), consistently reporting that children with lower levels of coordination perform poorer than their peers for balance, locomotor and ball skills. Consistently, the HMC group in the present study estimated better performances than the LMC group for all motor skill tasks; however, this difference was significant only for two of the tasks (jumping and WB).

The findings also indicated that, for both groups of children (LMC and HMC) the estimated and real locomotor (SLJ) and manipulative skills were associated, and that the estimation significantly predicts the real performance. Although real performance was correlated with estimation, it could only account for 9.6% (LMC) and 7.3% (HMC) of variation for the SLJ. For the throwing, real performance shares 14.4% (LMC) and 34.1% (HMC) of the variability in estimation, and for the kicking, 37.8% (LMC) and 28.5% (HMC) of the variability in estimation is shared by real performance. It is to be noted that a high percentage of the variability needs to be accounted for by other variables. It is difficult to directly compare the results to other studies, because researches in this field have not matched assessment of real and estimated skills as we did. On the other hand, existing studies on perceived and actual FMS have looked at gender interactions (Barnett et al., 2014; Liong et al., 2015) or time spent in physical activity (Barnett et al., 2014) using a pictorial instrument to evaluate the perceived skills. Our results indicate that the relationship between real and estimated motor competence is not constant along the spectrum of motor competence for all tasks. Although children who have lower real motor competence usually also exhibit lower estimated motor competence, as suggested by Stodden and collaborators (2008), in some tasks there are no significant differences between the perception of better and worse performers.

This study also found evidence that children with HMC tend to be more accurate when predicting their motor performance than children with LMC, at least in some tasks. Even though the HMC group was generally more accurate, differences in APE were only significant for the throwing and balance tasks. Although hypothesizing, we can argue that children with greater motor coordination may be involved in more opportunities and experiences to participate in varied motor activities, which may result in a greater ability to accurately estimate their action capabilities. The ability to make an accurate estimate of one's motor abilities seems to be task specific, as can be seen by the levels of accuracy and the differences between the accuracy of HMC and LMC children obtained for the different tasks. These findings are in agreement with other studies that found that children with serious impairment in the development of motor coordination are less able to detect changes in their action capabilities (Johnson, & Wade, 2009), being more likely to make inaccurate judgments (Johnson, & Wade, 2007). Within this framework, the co-occurrence of low motor coordination with greater difficulty in accurately perceiving the limits of action capabilities might be related with the occurrence of negative consequences of unsuccessful actions. The perception of success or failure in an action influences a child's future actions in the environment and possibly even his or her subsequent engagement in different physical activities and sports (Stodden et al., 2008).
In the present study, the LMC group exhibited a greater overestimation tendency than the HMC group. Previous studies have shown that children make judgment errors and frequently overestimate their abilities when judging several physical abilities (*e.g.,* Plumert, 1995; Rochat, 1995; Schwebel, & Bounds, 2003). This overestimation tendency can lead to failed action or injury (Plumert, & Schwebel, 1997). Our findings indicate that children in

the lowest quartile of motor coordination were more likely to overestimate their abilities when compared to children with high coordination level. These results support the idea that the motor coordination level can influence the ability to accurately perceive the limits of action capabilities. Even children with average/normal level of coordination have some inability to accurately perceive their action capabilities. Conversely, a higher level of coordination seems to be related with lower estimation errors.

Due to the characteristics of our sample, which did not include children with serious impairments in the development of motor coordination (*e.g.,* Haga, 2008), we could not investigate the differences between estimated and real motor competence along all the spectrum of motor competence. This is a limitation of the present study, which implies that our findings should not be generalized to children at risk for Developmental Coordination Disorder (DCD). However, since in our sample the typically developing children, with average coordination scores, made less accurate judgments than their peers with high coordination levels, it seems highly likely that children at risk for DCD would have an even greater inability to accurately perceive their action capabilities. Additional research is needed to further investigate this issue and to explore the possible mediators of the relationship between motor coordination and estimated motor competence.

4.5. Conclusion

The question of whether children take into account their perceptual motor skills when deciding about their abilities to perform a specific action, that is, *affordances*, is an important issue both in theory and practice. This study verified that children with the LMC level performed significantly poorer in FMS tasks than their peers with the HMC level, making also larger judgment errors about their action capabilities for two out of the four tasks (walking backwards on a beam, and throwing a ball into a soccer net). Therefore it is difficult to conclude that children with HMC are better estimating their performance than their peers with LMC (which were within the normal range for the KTK). These results have, however, important implications for the management and education of children with lower motor competence, which tend to less accurately estimate their motor abilities. Caregivers have an important role in managing environments for children, enabling them to learn about their action limits (Cordovil, Araújo, Pepping, & Barreiros, 2015), but in some cases intervention and rehabilitation programs that provide opportunities for lower motor competence children to improve the perception of their action limits will probably have an important impact in terms of child safety. A more accurate perception of action capabilities will help preventing unintentional injuries that occur during children's participation in sports and during the use of different equipments at home or in playgrounds. The fact that a higher motor competence seems to be related with a more accurate perception of action capabilities, highlights the importance of instructing children and giving them opportunities to both improving their motor proficiency and perceiving more accurately their motor abilities.

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CHAPTER 5

CONCLUDING REMARKS

Concluding remarks

The goal of this study was to investigate the relationship between estimated motor performance and real motor performance, in children from age 6 to 10 years, on a set of fundamental movement skills tasks (standing long jump, throwing, kicking, and WB). The novelty of this study is that the assessment of estimated performance exactly matches the assessment of real FMS performance.

The findings indicate that: (i) boys significantly estimate more than girls; (ii) boys perform significantly better than girls, except for the WB; (iii) children's real and estimated performances are positively associated, but the association is only weak to moderate; (iv) children exhibit an overestimation bias for the four assessed skills; (v) boys show an overestimation tendency, while for the SLJ, underestimation is more frequent in girls; (vi) children are more conservative in the WB task, a non-common action; (vii) with increasing age, children become more accurate, that is, more realistic in their self-estimation, and the differences between performance and estimation diminish. Children in the intermediate age group, on the other hand, presented a larger APE for some of the tasks (SLJ and kicking).

A secondary aim was to examine different coordination levels (highest *vs* lowest performers) within the relationship between estimated and real motor performance. The findings indicate that: (i) not surprisingly, children with the lowest coordination level perform significantly poorer in FMS tasks, than their HMC peers; (ii) the LMC group display greater estimation error about their action capabilities for WB and throwing tasks; and, (iii) both groups overestimate their performance in all the tasks, except for the HMC group and the WB task, which showed a greater frequency of accuracy. The difference between the HMC and LMC groups was only significant for two of the four tasks, and so it is difficult to clearly conclude that children with HMC are more capable of estimating their performance, than children with LMC. This issue should be further investigated by using different tasks or instruments to assess motor coordination.

In general, it is possible to conclude that children in the studied age span tend to overestimate their performance in motor skills, particularly in skills which they are more familiar with. This conclusion is also supported by previous studies, and indicated above.

The results of this study should raise awareness of professionals working with children and bring out additional question to be investigated further. It should be also noted that this study possesses some limitation, which we enumerate in the following section.

Limitations

- The results obtained in a secure environment may not be generalizable risky real-life situations, that is, children might have overestimated their performance, more than they would in real life, due the safe environment provided and the low possibility of harm. It is likely that they would be more cautious if they would execute the same tasks with some risk involved, such as jumping over a cliff. On the other hand, and referring specifically to the jumping over a cliff, it is unlikely that the task would be performed using a standing long jump, which was the evaluated task;
- This investigation used a non-common skill (walking backwards), to assess the fundamental stability skill; Although this might seem to be a limitation of the study, because children might had more difficulty in estimating a non-familiar task, it raises interesting questions about the influence of specific motor experience in the accuracy of motor estimation;
- The chosen fundamental stability task (walking backwards on a balance beam), used to measure the estimation and real performance was very similar to one of the tasks used to measure motor coordination through KTK battery (walking backwards on 3 balance beams with 3 different widths);
- The battery used to assess motor coordination (KTK) is probably not sufficiently sensitive to guarantee a good discrimination of the level of coordination of children.

Implications

- Matching the assessment of real and estimated FMS will help professionals to understand this relationship in childhood;
- Children seem to be unable to accurately perceive their motor performance and consistently overestimate their competence in most tasks. This is especially true in children in the LMC level;
- Experience in estimating and performing different motor tasks might increase the accuracy in estimating motor performance, which can lead to an increase in the safety of motor practices, and the prevention and reduction of unintentional injuries;
- This study has important implications for early childhood programs; It shows that children might benefit from intervention and rehabilitation programs, which provide

opportunities and experiences in order to accurately perceive the limits of their motor actions.

Suggestions for Future Research

- Taking into account the results presented in this thesis, we believe it would be relevant to address other FMS tasks, in particular skills that constitute the motor repertoire of children;
- In addition, the longitudinal associations between estimated and real FMS are of special interest;
- Future research should explore the causal mechanisms that lead to overestimation in childhood, and how overestimation has an impact on children motor development and safety;
- Using estimation and chronological age as variables was shown to be insufficient to explain the obtained results. Therefore other variables should also be accounted for the prediction of actual performance on the motor tasks. One such variable could be, for example, the time spent doing physical activities;
- Additional research should also involve children with motor disorders, such as developmental coordination disorder;
- Another point that has not been previously considered is to what extent do both the emotional and behavioral aspects of the parents and of the children affect the overestimation of the latter.