Human Movement Science 43 (2015) 61–66

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Longitudinal patterns of change in eye–hand coordination in children aged 8–16 years

Lennon J. Wicks [a,*], Rohan M. Telford [b], Ross B. Cunningham [c], Stuart J. Semple [a], Richard D. Telford [a]

[a] University of Canberra, Faculty of Health, Research Institute for Sport and Exercise, Australia
[b] University of Canberra, Faculty of Health, Centre for Research and Action in Public Health, Australia
[c] Australian National University, Fenner School of Environment and Society, College of Medicine, Biology and Environment, Australia

ARTICLE INFO

Article history:
Received 30 April 2015
Revised 9 July 2015
Accepted 10 July 2015
Available online 24 July 2015

Keywords:
Object control
Coordination
Physical activity
Development
Motor skills

ABSTRACT

Enhanced eye–hand coordination (EHC) is associated with greater participation in physical activity. No longitudinal studies have examined the change in throw–catch EHC from childhood to mid-adolescence. We investigated the development of EHC with an object control test from childhood to mid-adolescence in boys and girls. Evaluated at age 8, 10, 12 and 16 years, EHC was measured as the aggregate success rate of a throw and wall-rebound catch test. The test involved 40 attempts of progressive increasing difficulty, as determined by increased distances from a wall and transitions from two-handed to one-handed catches. Outcomes were treated as quasi-binomial and modelled by generalised linear mixed logistic regression analysis. EHC improved with age from childhood to mid-adolescence, although boys were more adept at each age ($p < 0.001$). The patterns of change in EHC with increasing age varied according to the degree of difficulty of the task ($p < 0.001$); throw and two-handed catch proficiency developing earlier than throw and one-handed catch in both sexes. Boys' EHC was better than girls' as early as age 8 years and male proficiency was maintained through to mid-adolescence. The proficiency of throw and two-handed catch rates developed faster than throw and one-handed catch rates for both sexes.

1. Introduction

Increasing evidence suggests that fundamental motor skill (FMS) proficiency has a critical role to play in health, as motor skill ability has been shown to predict physical activity levels in pre-schoolers (Williams et al., 2008), pre-teenagers (Barnett, van Beurden, Morgan, Brooks, & Beard, 2009; Holfelder & Schott, 2014) and adolescent youth (Barnett, van Beurden, Morgan, Brooks, & Beard, 2008; Barnett et al., 2009). Furthermore motor skill proficiency has been shown to be positively associated with fitness, sport participation (Cattuzzo et al., 2014; Okely, Booth, & Patterson, 2001; Stodden et al., 2008; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006) and negatively with weight status (Lubans, Morgan, Cliff, Barnett, & Okely, 2010).

Eye–hand coordination (EHC) is a key component of motor skill ability involving the coordinated control of eye movement with hand movement to aid reaching or grasping an object (Crawford, Medendorp, & Marotta, 2004). We chose to focus on this skill, because it is a characteristic that underlies success in most sports, schoolyard games and activities. EHC is

* Corresponding author at: Building 12, Level C, Room 5, University of Canberra, Bruce, ACT 2601, Australia.
E-mail address: Lennon.Wicks@canberra.edu.au (L.J. Wicks).

http://dx.doi.org/10.1016/j.humov.2015.07.002
0167-9457/

associated positively with physical activity and negatively with obesity (Telford et al., 2013). Specific evidence exists affirming the importance of object control competence, as opposed to locomotor competence, in predicting physical activity and fitness levels (Barnett, Morgan, van Beurden, Ball, & Lubans, 2011; Barnett et al., 2009; Cohen, Morgan, Plotnikoff, Callister, & Lubans, 2014; Vlahov, Baghurst, & Mwavita, 2014). The importance of EHC is recognised clinically as well; catching ability previously having been used from a clinical perspective to assess motor impairment (Van Waelvelde, De Weerdt, De Cock, & Smits-Engelsman, 2004).

Given the potential influence of EHC on the likelihood to engage sport and physical activity, it is beneficial to understand how this skill develops from childhood to adolescence; especially given the premise that children do not necessarily learn FMS "naturally" (Goodway & Branta, 2003; Goodway, Suminski, & Ruiz, 2003). Consequently, there has been a call for longitudinal studies of children investigating the associations between motor skill ability, competency and psychophysiological characteristics (Lubans et al., 2010).

We set out to conduct such a study, focussing on EHC. As a measure of EHC, we employed a test of object control, measuring the competency of a child to perform a ball throw and wall-rebound catch. This particular test was selected due to its direct applicability to ball sports, its ease of administration, objectivity and reliability, together with its demonstrated relationships with physical activity and obesity (Telford et al., 2013; Van Waelvelde et al., 2004).

Although a straightforward test, the skill required is in reality, quite a complex one. The task of catching alone requires movement of the hands and temporal assessment of the speed, direction, weight, and size of the ball. Further, there is the additional requirement of judging the speed and elevation of the throw as well as the anticipation of the angle and speed of the rebound from the wall. Moreover, the test involves variations to the degree of difficulty, introduced by restriction of the manner in which the ball is caught, either by two hands or one hand and distance from the wall.

The primary objective of this study was to investigate the development of throw–catch EHC from childhood to mid-adolescence; to compare EHC and its development in boys and girls; and to determine the effect of difficulty of EHC task on rate of development.

2. Methods

2.1. Participants

Initially 355 boys and 373 girls, aged 8 years, from 29 public primary schools were evaluated in this 8 year longitudinal study. This study is part of the Lifestyle of our Kids (LOOK) project, the overall outline has been described previously (Telford et al., 2009).

2.2. Throw and wall-rebound catch test

A tennis ball was thrown overarm against a solid wall and a rebound catch attempted. The test took place at increasing distances from a wall. There were two rounds consisting of five attempts made at each of the following distances: 0.5 m, 1.0 m, 1.5 m and 2.0 m. In the first round participants attempted to catch the ball with two hands; in the second round with their preferred hand. Prior to beginning the test, participants received an explanation and a demonstration of an overarm throw and catch. Participants were allowed three familiarisation attempts prior to attempting the test. Successful catches were recorded. The maximum achievable score was 40. Evaluations were conducted at ages 8, 10, 12 and 16 years.

Test–retest reliability of this specific throw and wall-rebound catch test was measured with a group ($n = 21$) of 10 year-olds who completed the test twice within a 3 h interval. Intra-class correlations were calculated as 0.82 (95% CI: 0.60, 0.92) for the throw and two-handed catch and 0.90 (95% CI: 0.78, 0.96) for the throw and one-handed catch (Telford et al., 2013).

This study was approved by the Australian Capital Territory Health Community Care Human Research Ethics Committee, the Ethics Committee at The Australian Institute of Sport and the local jurisdiction Department of Education and Training. Parental and child consent was obtained for all measures in this study, and children understood that their participation was entirely voluntary.

2.3. Statistical methods

The number of successful outcomes was treated as a quasi-binomial response and modelled by generalised linear mixed logistic regression analysis. Given the nature of the test, and that more children are likely to achieve the maximum score of 40 as they become older, the observations are best considered as proportions data and the underlying measure of EHC is therefore reported as the probability of success.

The model used fits within the general framework for generalised linear mixed models (Galwey, 2008). This method of statistical analysis was previously used to describe longitudinal patterns of EHC change (Telford et al., 2013). Subjects were treated as random effects to account for the within child correlations. Age and gender were treated as fixed effects. The statistical significance of effects was assessed by adjusted Wald statistics (Kenward & Roger, 1997). Model checking procedures