JIDR Journal of Intellectual Disability Research
Published on behalf of mencap and in association with IASSID

Journal of Intellectual Disability Research doi: 10.1111/j.1365-2788.2012.01569.x

VOLUME 57 PART 7 pp 627–634 JULY 2013

An external focus of attention enhances motor learning in children with intellectual disabilities

S. Chiviacowsky,[1] G. Wulf[2] & L. T. G. Ávila[1]

1 *Physical Education School, Federal University of Pelotas, Pelotas, RS, Brazil*
2 *Department of Kinesiology and Nutrition Sciences, University of Nevada, Las Vegas, NV, USA*

Abstract

Background The present study examined whether the learning benefits of an external focus of attention (i.e. on the movement effect) relative to an internal focus (i.e. on the movement), found previously in non-disabled children and adults would also be found in children with intellectual disabilities (IDs).
Methods Participants ($n = 24$; average age: 12.2 years) with mild intellectual deficiency (IQ = 51–69) practiced throwing beanbags at a target. In the external focus group, participants were instructed to direct their attention to the movement of the beanbag, while in the internal focus group, participants were asked to direct their attention to the movement of their hand. The practice phase consisted of 40 trials, and attentional focus reminders were given after every third trial. Learning was assessed 1 day later by retention and transfer (greater target distance) tests, each consisting of 10 trials. No focus reminders were given on that day.
Results The external focus group demonstrated more effective learning than the internal focus group, as evidenced by more accurate tosses on the transfer test.
Conclusions The present findings show that instructions that induce an external focus of attention can enhance motor learning in children with IDs.

Correspondence: Prof Suzete Chiviacowsky, Physical Education School, Federal University of Pelotas, Rua Luís de Camões, 625, Pelotas, RS 96055-030, Brazil (e-mail: schivi@terra.com.br).

Keywords instructions, learning disabilities, motor control, throwing

Introduction

Intellectual disability (ID) is frequently described as mental deficiency, mental retardation, or learning disability (Mercadante *et al.* 2009) and 'is characterised by significant limitations both in intellectual functioning and in adaptive behavior, which covers many everyday social and practical skills' (American Association on Intellectual and Developmental Disabilities 2011). Individuals with ID typically show developmental delays and experience difficulties in performing motor skills when compared with typical individuals, as a number of studies have shown (e.g. Connor-Kuntz & Dummer 1996; Goodway & Rudisill 1997; Hamilton *et al.* 1999; Simons *et al.* 2008; Vuijk *et al.* 2010; Westendorp *et al.* 2011).

It has been suggested that the motor performance delay observed in children with mild ID is related to their impaired intellectual functioning. According to Diamond (2000), motor development is often compromised when cognitive development is impaired. Until recently the prefrontal cortex and cerebellum were believed to have different functions, with the former being assumed to be important primarily for complex cognitive abilities, and the latter for motor skills. Yet, there is now evidence for a close relationship between the two, in both typical participants (e.g. Awh *et al.* 1996; Jonides *et al.* 1997) and persons with brain damage (e.g. Schmahmann & Sherman 1998), as deficiencies in cognitive development appear to be associated with motor disabilities. In fact, a direct connection between cognitive functions and motor performance in children with ID has been shown in some studies. For example, results by Wuang *et al.* (2008) suggested that motor performance varies as a function of IQ in children diagnosed with mild ID. Also, Hartman *et al.* (2010) demonstrated that the impairment in motor skills was interrelated with impairment in higher-order executive functions, with children with mild ID scoring higher impairment than children with borderline ID. Executive functions include of the formation of goals, making and executing plans, attentional control, and perseveration on a given task. They are essential to adaptive behaviour and effective performance, and are, therefore, preconditions for success in everyday life (Jurado & Rosselli 2007). However, strong experimental support is still lacking regarding the direct connection between motor performance/development and cognitive functions in children with ID, as only a few studies have utilised cross-sectional designs (e.g. Wuang *et al.* 2008; Hartman *et al.* 2010). Therefore, it is unclear whether disability in cognitive function is responsible for delayed motor performance, or vice versa, or if perhaps another variable contributes to both.

Changes in the motor behaviour of persons with ID can be expected with targeted interventions (Lotan *et al.* 2004; Shin *et al.* 2009; Shih *et al.* 2010). Importantly, Westendorp *et al.* (2011) demonstrated the existence of a relationship between the development of gross motor skills and organised sport participation in children with ID. Their study showed a positive relationship between object-control skills and participation of intellectually challenged children, supporting the notion that the development of object control (e.g. throwing) may contribute to children's future sport participation. The development and learning of motor skills is fundamental to human development. Yet, studies examining factors that can enhance the learning of motor skills in intellectually challenged children are limited.

One factor that has consistently been shown to benefit motor learning in typical learners is the focus of attention induced by instructions or feedback (for a review, see Wulf 2007). Specifically, if attention is directed to the effect of the performer's movements on the environments, such as an implement (e.g. ball, golf club, tennis racket, skateboard) (i.e. inducing an external focus), motor learning is generally enhanced, compared with attention directed to the body movements themselves (i.e. inducing an internal focus of attention) or no focus instructions (control conditions). In the first study that demonstrated the effectiveness of instructions inducing an external relative to an internal focus of attention (Wulf *et al.* 1998) in young adults, the learning of dynamic balance tasks was enhanced when participants' attention was directed to the movements of the platform on which they were standing (specifically, wheels on a ski simulator platform or markers on a balance platform; Wulf *et al.* 1998, Experiments 1 and 2, respectively) as compared with the movements of their feet. Group differences were seen on delayed retention tests (without focus instructions or reminders), demonstrating that they reflected differential effects of the instructions on learning. Since then, numerous researchers have replicated the benefits of instructions or feedback inducing an external focus. For example, studies have demonstrated learning advantages of an external focus for sport skills, including hitting golf balls (e.g. Wulf & Su 2007; Bell & Hardy 2009), basketball free-throw shooting (Al-Abood *et al.* 2002; Zachry *et al.* 2005), dart throwing (Marchant *et al.* 2007), long jump (Porter *et al.* 2010), volleyball serves and soccer kicks (Wulf *et al.* 2002), as well as soccer throw-ins (Wulf *et al.* 2010a). The benefits of an external relative to an internal focus have been shown not only for a variety of motor skills, but also for different levels of expertise (novices, advanced performers, experts) and age groups (adults, adolescents, children) as well as for healthy individuals and those with motor impairments, for instance, because of Parkinson's disease (Landers *et al.* 2005; Wulf *et al.* 2009) or stroke (Fasoli *et al.* 2002).

The differential effects of internal versus external foci have been explained with the constrained action hypothesis (Wulf *et al.* 2001), according to which an internal focus on the body induces a conscious type of control. As a consequence, individuals tend to constrain their motor system by interfering with automatic control mechanisms that have the capacity to control movements effectively and efficiently. In contrast, focusing on the movement effect promotes a more automatic mode of control. It allows for the utilisation of unconscious, fast and reflexive control processes, with the result that the desired outcome is achieved almost as a by-product (e.g. Wulf *et al.* 2001, 2010b; Lohse *et al.* 2010).

Given the robustness of the attentional focus effect on motor skill learning, we wanted to investigate whether similar learning benefits of inducing an external focus would be found in children with ID. Even though numerous studies have examined the effects of attentional focus on motor learning, very few have included children (e.g. Wulf *et al.* 2010a). Also, studies with persons who have motor and/or mental problems such as Parkinson's disease (Landers *et al.* 2005; Wulf *et al.* 2009) or stroke (Fasoli *et al.* 2002) are rare. Yet, the fact that performance and learning enhancements with an external focus were seen in those populations as well – including improved throwing form (Wulf *et al.* 2010a), enhanced balance (Landers *et al.* 2005; Wulf *et al.* 2009), as well as greater movement speed, and presumably automaticity (Fasoli *et al.* 2002) – led us to hypothesise that children with ID may benefit from external focus instructions as well. Such a finding would be important not only theoretically, but also for many practical applications as everyday social and sport skills could potentially be enhanced by simply by wording instructions differently.

Participants in the present study were asked to throw beanbags at a target. While one group received instructions that directed their attention to the movement of the beanbag (external focus), the other group was instructed to focus their attention on the movement of their hand. Following a practice phase with intermittent attentional focus reminders, learning was assessed 1 day later by retention and transfer tests. No focus instructions or reminders were given on the second day. The retention test involved the same target distance as that used during practice (2 m). For the transfer test, the target distance was increased (3 m). The specific purpose of transfer tests is to examine the generalisability of what was learned to novel conditions. Also, transfer tests are often more sensitive measures of learning (e.g. Wrisberg & Wulf 1997; Lai & Shea 1998; Chiviacowsky & Wulf 2002, 2005). We hypothesised that external focus group participants would demonstrate greater throwing accuracy on both tests than the internal focus group, but perhaps particularly on the transfer test.

Method

Participants

Twenty-four children (10 girls and 14 boys) with ID, ranging in age from 10 to 14 years (mean age 12.21; SD = 1.31), were recruited from special schools for individuals with ID. Oral assent was obtained from the participants, and written consent from their parents/guardians and the schools. The study was approved by the university's ethics committee. The participants were unaware of the purpose of the experiment, and the task was novel to all of them.

Participants were selected using the following inclusion criteria: Mild ID (IQ = 51–69), as defined by the Wechsler Scale of Intelligence for children (Wechsler 1991; Cruz 2005), recognised ability to understand basic verbal communication, and independence from personnel, assistive devices, or support services. Participants were excluded if they showed any significant perceptual deficits (e.g. visual, auditory), had a clinical history of other neurological problems (e.g. Down syndrome), or any other behavioural problems.

Apparatus and task

The task involved tossing beanbags (100 g) with the dominant arm at a vertical target (bull's eye). The target's centre was 120 cm above the floor (see Fig. 1). The bull's eye had a radius of 10 cm. Concentric circles with radii of 20, 30, 40, . . . 90, and 100 cm, respectively, around the target served as

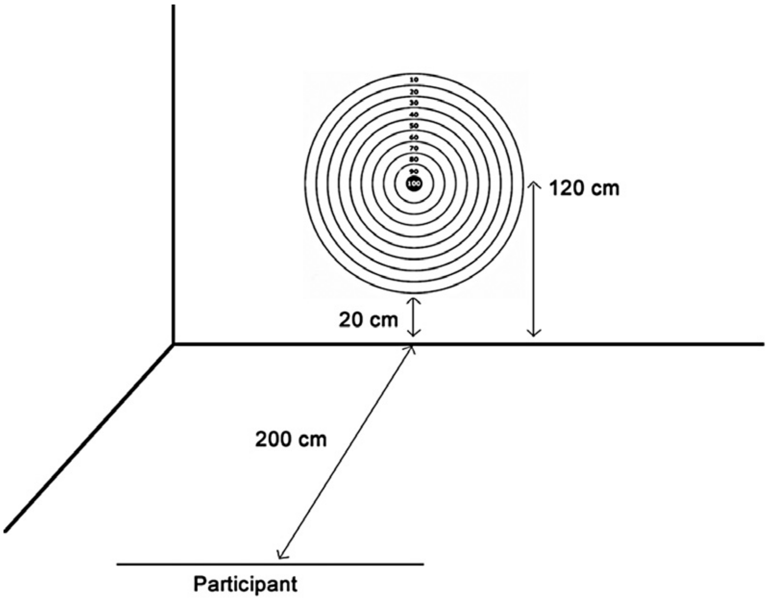

Figure 1 Schematic of the experimental setup.

zones to assess throwing accuracy. One hundred points were awarded if the beanbag hit the target. If it hit one of the other zones, or outside the circles, 90, 80, 70, . . . 20, 10, or 0, points were recorded, respectively. Participants threw beanbags at the target from a distance of 2 m during the practice phase and retention test, and from a 3 m distance on the transfer test.

Procedure

The experiment was conducted in a separated room of the children's school. Each participant performed the task individually. As some studies have found gender differences in throwing performance, based on boys' typically more extensive experience with throwing tasks (Thomas & French 1985; Pulito Runion *et al.* 2003; Ehl *et al.* 2005), participants were quasi-randomly assigned to the internal or external focus groups to ensure that there were similar numbers of boys and girls in the external focus group (5 girls and 6 boys; mean age: 12.00 years, SD = 1.26) and internal focus group (6 girls and 7 boys; mean age: 12.27 years, SD = 1.34).

The task was explained to the participants in condition-appropriate language. Before the beginning of the practice phase, the experimenter explained and demonstrated the basic overhand throwing movement to each participant. The preferred hand was determined by asking participants about their favourite hand for drawing or writing. The general instructions regarding the task goal and throwing motion were the same for all participants. Following the general instructions, participants in the internal focus group were asked to focus their attention on the movements of their throwing hand, whereas participants in the external focus group were asked to focus their attention to the movement of the beanbag while throwing. The experimenter made sure that all participants understood the instructions. Specifically, participants were asked to verbally repeat what they were expected to do, and to touch the target (bull's eye) they were aiming for. Participants were given attentional focus reminders after every third trial during the practice phase. All participants performed 40 practice trials. Retention and transfer tests, conducted 1 day after the practice session, consisted of 10 trials each. No attentional focus reminders were given on the second day.

Data analysis

Accuracy scores on the 40 practice trials were averaged across blocks of eight trials, resulting in five blocks, and analysed in a 2 (group: external vs.

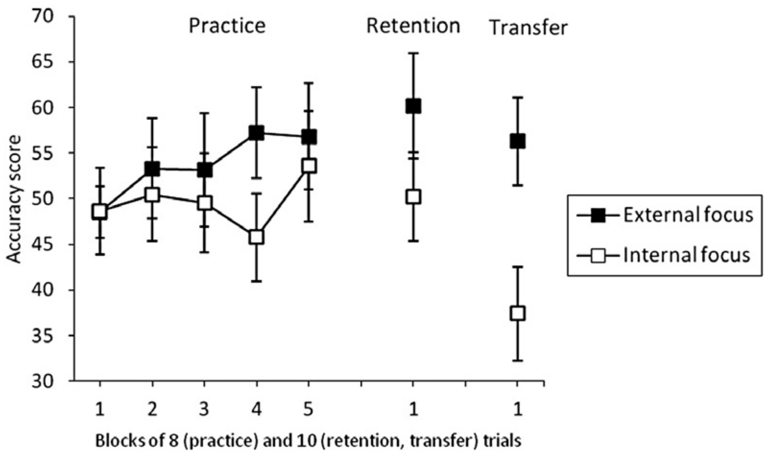

Figure 2 Accuracy scores of the external and internal focus groups in practice (5 blocks of 8 trials), retention and transfer (10 trials each). Error bars represent standard errors.

internal focus) × 5 (blocks) analysis of variance (ANOVA) with repeated measures on the last factor. Scores on the retention and transfer tests were averaged across 10 trials each and analysed in a 2 (group) × 2 (test: retention, transfer) ANOVA with repeated measures on the last factor to assess group differences as a function of the type of test.

Results

Practice

The internal and external focus groups tended to increase their accuracy scores across the practice phase, with the external focus group having somewhat higher scores than the internal focus group (see Fig. 2, left). The main effects of group, $F_{1,22} < 1$, and block, $F_{4,88} = 1.21$, $P > 0.05$, as well as the interaction of group and block, $F_{4,88} = 1.03$, $P > 0.05$, failed to reach significance, however.

Retention and transfer

As can be seen from Fig. 2 (right), on the retention and transfer tests the external focus group had higher accuracy scores (60.2 and 56.3, respectively) than the internal focus group (50.2 and 38.4, respectively). The learning advantage of the external focus condition was particularly pronounced on the transfer test with the novel (greater) target distance. The main effect of group was significant, $F_{1,22} = 5.25$, $P < 0.05$, $\eta_p^2 = 0.19$ (small to medium effect size). Also, the main effect of test was significant, $F_{1,22} = 14.10$, $P < 0.001$, $\eta_p^2 = 0.39$ (large effect size), indicating a general decrease in throwing accuracy on the transfer relative to the retention test. The interaction of group and block reached borderline significance, $F_{1,22} = 4.01$, $P = 0.058$, $\eta_p^2 = 0.15$ (small effect size). *Post hoc* tests showed that the internal focus group demonstrated a significant decrease in throwing accuracy from retention to transfer ($P < 0.001$), whereas the external focus group's performance did not differ between tests ($P > 0.05$).

Discussion

Children with ID differ from typical children in various regards (e.g. Hamilton *et al.* 1999; Simons *et al.* 2008). For example, this population has a high prevalence of attentional control deficits (e.g. Carretti *et al.* 2010; Neece *et al.* 2011), and the rate of attention-deficit/hyperactivity disorder (ADHD) is over three times as high as that in typical individuals (Neece *et al.* 2011). A recent study by Mauerberg-deCastro *et al.* (2009) showed that children with ID were also more vulnerable to distraction than typical children. Given these attentional issues, it was unclear whether children with ID would benefit from external relative to internal focus instructions. Yet, the present results showed that the learning advantage of instructions inducing an external attentional focus generalised to mentally challenged children. Despite the small difference in the wording of the instructions – which essentially differed by one word, as in most previous studies – those that directed learners' attention to the beanbag movement rather than their own (hand) movement resulted in more effective skill learning. It should be pointed out that the instructions given during practice had a lasting effect, that is, they were evident on delayed tests during which no focus reminders were given. Moreover, the benefits of external focus instructions during practice generalised to a novel version of the task (transfer test) that required the extrapolation of movement parameters (e.g. absolute force) based on practice experience with another task version (Schmidt 1975). Group differences on this more challenging test were, in fact, larger than they were on the retention test. The additional task demands of having to adapt a movement pattern to a novel situation tend to make transfer tests more sensitive measures of learning, and it is not unusual for group differences to be more pronounced on transfer relative to retention tests (Wrisberg & Wulf 1997; Lai & Shea 1998; Chiviacowsky & Wulf 2002, 2005).

Studies have demonstrated that the adoption of an external relative to an internal focus results in more automatic movements, characterised by fast, reflexive movement adjustments (e.g. Wulf *et al.* 2001), as well as greater movement efficiency. Several recent studies have shown reduced muscular (electromyographical) activity with an external relative to an internal focus – sometimes combined with greater movement accuracy, for example, in throwing tasks (e.g. Lohse *et al.* 2010), or greater maximum force production (Wulf *et al.* 2010b). In addition, Lohse *et al.* (2011) found reduced co-contractions between the agonist and antagonist muscles and a more efficient pattern of motor unit recruitment both within and between muscles. Thus, the external focus instructions in the present study may have led to a more automatic, efficient, and consequently accurate throwing pattern than the internal focus instructions. Yet, future studies are necessary to examine more directly the effects of attentional foci on movement efficiency in individuals with mental and attentional challenges (e.g. ADHD).

An external focus has also been shown to be associated with reduced attentional demands (Wulf *et al.* 2001). In the study by Wulf *et al.*, probe reactions times were shorter – indicating greater spare attentional capacity – when participants (young, unimpaired adults) were instructed to adopt an external relative to an internal focus. According to Numminena *et al.* (2002), tasks requiring visuo-spatial working memory may be more demanding for individuals with ID than for typical participants. Thus, the attentional capacity freed up by an external focus may also have contributed to the learning advantages seen on the retention test, and particularly on the transfer test that required the selection of novel movement parameters. Again, future studies may shed more light on working memory demands as a function of attentional focus in this population.

The present findings are in line with those of a previous study (Wulf *et al.* 2010a) in which typical 10-year-old children's motor learning (soccer throw-in) benefited from instructions or feedback inducing an external focus of attention. Yet, studies on the effects of attentional focus with children are still rare. In future studies, it would therefore be interesting to examine these effects in younger age groups as well as in children with other (motor) problem, such as ADHD. It may also be useful to include control conditions without specific attentional focus instructions in future studies with children.

Instructions or feedback given in practical settings typically involve mentioning of body parts or movements. This may also be one reason why learners presumably spontaneously focus on their body movements when left to their own devices, that is, in control conditions without focus instructions (e.g. Wulf *et al.* 1998, 2003, 2009; Freudenheim *et al.* 2010). In those studies, control conditions almost always resulted in similar performances as internal focus conditions, whereas external focus conditions led to enhanced performance or learning. Put another way, instructions inducing an internal focus have not been demonstrated to be more effective than no instructions. Thus, there is clearly room for optimising motor learning. As the present results demonstrate, wording instructions in a way that they direct learners' attention to the intended movement effect (i.e. induce an external focus) can facilitate learning in children with ID. Fundamental motor skills such as throwing are considered building blocks for the development of more complex sport skills. Increasing their capacity to successfully participate in sport activities can open important opportunities for children with ID – allowing them not only to further improve their motoric competencies, and possibly self-esteem, but also to engage in social interactions with others.

References

Al-Abood S. A., Bennett S. J., Hernandez F. M., Ashford D. & Davids K. (2002) Effects of verbal instructions and image size on visual search strategies in basketball free throw shooting. *Journal of Sport Sciences* **20,** 271–8.

American Association on Intellectual and Developmental Disabilities (2011) Available at: http://www.aaidd.org/content_100.cfm?navID=21 (retrieved 5 April 2012).

Awh E., Jonides J., Smith E. E., Schumacher E. H., Koeppe R. A. & Katz S. (1996) Dissociation of storage and rehearsal in verbal working memory: evidence from positron emission tomography. *Psychological Science* **7,** 25–31.

Bell J. & Hardy J. (2009) Effects of attentional focus on skilled performance in golf. *Journal of Applied Sport Psychology* **21,** 163–77.

Carretti B., Belacchi C. & Cornoldi C. (2010) Difficulties in working memory updating in individuals with intellectual disability. *Journal of Intellectual Disability Research* **54,** 337–45.

Chiviacowsky S. & Wulf G. (2002) Self-controlled feedback: does it enhance learning because performers get feedback when they need it? *Research Quarterly for Exercise and Sport* **73,** 408–15.

Chiviacowsky S. & Wulf G. (2005) Self-controlled feedback is effective if it is based on the learner's performance. *Research Quarterly for Exercise and Sport* **76,** 42–8.

Connor-Kuntz F. & Dummer C. (1996) Teaching across the curriculum: language-enriched physical education for preschool children. *Adapted Physical Activity Quarterly* **13,** 302–15.

Cruz M. B. Z. (2005) WISC III: escala de inteligência Wechsler para crianças: manual. *Avaliação Psicológica* **4,** 199–201.

Diamond A. (2000) Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Development* **71,** 44–56.

Ehl T., Roberton M. A. & Langendorfer S. J. (2005) Does the throwing 'gender gap' occur in Germany? *Research Quarterly for Exercise and Sport* **76,** 488–93.

Fasoli S. E., Trombly C. A., Tickle-Degnen L. & Verfaellie M. H. (2002) Effect of instructions on functional reach in persons with and without cerebrovascular accident. *American Journal of Occupational Therapy* **56,** 380–90.

Freudenheim A. M., Wulf G., Madureira F., Corrêa U. C. & Corrêa S. C. P. (2010) An external focus of attention results in greater swimming speed. *International Journal of Sports Science & Coaching* **5,** 533–42.

Goodway J. D. & Rudisill M. E. (1997) Perceived physical competence and actual motor skill competence of African American preschool children. *Adapted Physical Activity Quarterly* **14,** 314–26.

Hamilton M. L., Goodway J. D. & Haubenstricker J. (1999) Parent-assisted instruction in a motor skill program for at-risk preschool children. *Adapted Physical Activity Quarterly* **16,** 415–26.

Hartman E., Houwen S., Scherder E. & Visscher C. (2010) On the relationship between motor performance and executive functioning in children with intellectual disabilities. *Journal of Intellectual Disability Research* **54,** 468–77.

Jonides J., Schumacher E. H., Smith E. E., Lauber E. J., Awh E., Misnoshima S. *et al.* (1997) Verbal memory load affects regional brain activation as measured by PEY. *Journal of Cognitive Neuroscience* **9,** 462–75.

Jurado M. B. & Rosselli M. (2007) The elusive nature of executive functions: a review of our current understanding. *Neuropsychology Review* **17,** 213–33.

Lai Q. & Shea C. H. (1998) Generalized motor program (GMP) learning: effects of reduced frequency of knowledge of results and practice variability. *Journal of Motor Behavior* **30,** 51–9.

Landers M., Wulf G., Wallmann H. & Guadagnoli M. A. (2005) An external focus of attention attenuates balance impairment in Parkinson's disease. *Physiotherapy* **91,** 152–85.

Lohse K. R., Sherwood D. E. & Healy A. F. (2010) How changing the focus of attention affects performance, kinematics, and electromyography in dart throwing. *Human Movement Science* **29,** 542–55.

Lohse K. R., Healy A. F. & Sherwood D. E. (2011) Neuromuscular effects of shifting the focus of attention in a simple force production task. *Journal of Motor Behavior* **43,** 173–84.

Lotan M., Isakov E., Kessel S. & Merrick J. (2004) Physical fitness and functional ability of children with intellectual disability: effects of a short-term daily treadmill intervention. *Scientific World Journal* **14,** 449–57.

Marchant D., Clough P. & Crawshaw M. (2007) The effects of attentional focusing strategies on novice dart throwing performance and their task experiences. *International Journal of Sport and Exercise Psychology* **5,** 291–303.

Mauerberg-deCastro E., Cozzani M. V., Polanczyk S. D., Paula A. I., Lucena C. S. & Moraes R. (2009) Motor perseveration during an 'A not B' task in children with intellectual disabilities. *Human Movement Science* **28,** 818–32.

Mercadante M. T., Evans-Lackob S. & Paula C. S. (2009) Perspectives of intellectual disability in Latin American countries: epidemiology, policy, and services for children and adults. *Current Opinion in Psychiatry* **22,** 469–74.

Neece C. L., Baker B. L., Blacher J. & Crnic K. A. (2011) Attention-deficit/hyperactivity disorder among children with and without intellectual disability: an examination across time. *Journal of Intellectual Disability Research* **55,** 623–35.

Numminena H., Serviceb E. & Ruoppila I. (2002) Working memory, intelligence and knowledge base in adult persons with intellectual disability. *Research in Developmental Disabilities* **23,** 105–18.

Porter J. M., Ostrowski E. J., Nolan R. P. & Wu W. F. W. (2010) Standing long-jump performance is enhanced when using an external focus of attention. *Journal of Strength & Conditioning Research* **24,** 1746–50.

Pulito Runion B., Roberton M. A. & Langendorfer S. J. (2003) Forceful overarm throwing: a comparison of two cohorts measured 20 years apart. *Research Quarterly for Exercise and Sport* **74,** 324–30.

Schmahmann J. D. & Sherman J. C. (1998) The cerebellar cognitive affective syndrome. *Brain* **121,** 561–79.

Schmidt R. A. (1975) A schema theory of discrete motor skill learning. *Psychological Review* **82,** 225–60.

Shih C. H., Shih C. T. & Chiu H. C. (2010) Using an extended automatic target acquisition program with dual cursor technology to assist people with developmental disabilities improve their pointing efficiency. *Research in Developmental Disability* **31,** 1091–101.

Shin J. Y., Nhan N. V., Lee S. B., Crittenden K. S., Flory M. & Hong H. T. (2009) The effects of a home-based intervention for young children with intellectual disabilities in Vietnam. *Journal of Intellectual Disability Research* **3,** 339–52.

Simons J., Daly D., Theodorou F., Caron C., Simons J. & Andoniadou E. (2008) Validity and reliability of the TGMD-2 in 7–10-year-old Flemish children with intellectual disability. *Adapted Physical Activity Quarterly* **25,** 71–82.

Thomas J. R. & French K. E. (1985) Gender differences across age in motor performance: a meta-analysis. *Psychological Bulletin* **98,** 261–82.

Vuijk P. J., Hartman E., Scherder E. & Visscher C. (2010) Motor performance of children with mild intellectual disability and borderline intellectual functioning. *Journal of Intellectual Disability Research* **54,** 955–65.

Wechsler D. (1991) *Manual for the Wechsler Intelligence Scale for Children*, 3rd edn. Psychological Corporation, San Antonio, TX.

Westendorp M., Houwen S., Hartman E. & Visscher C. (2011) Are gross motor skills and sports participation related in children with intellectual disabilities? *Research in Developmental Disabilities* **32,** 1147–53.

Wrisberg C. A. & Wulf G. (1997) Diminishing the effects of reduced frequency of knowledge of results on generalized motor program learning. *Journal of Motor Behavior* **29,** 17–26.

Wuang Y. P., Wang C. C., Huang M. H. & Su C. Y. (2008) Profiles and cognitive predictors of motor functions among early school-age children with mild intellectual disabilities. *Journal of Intellectual Disability Research* **52,** 1048–60.

Wulf G. (2007) *Attention and Motor Skill Learning*. Human Kinetics, Champaign, IL.

Wulf G. & Su J. (2007) An external focus of attention enhances golf shot accuracy in beginners and experts. *Research Quarterly for Exercise and Sport* **78,** 384–9.

Wulf G., Höß M. & Prinz W. (1998) Instructions for motor learning: differential effects of internal versus external focus of attention. *Journal of Motor Behavior* **30,** 169–79.

Wulf G., McNevin N. H. & Shea C. H. (2001) The automaticity of complex motor skill learning as a function of attentional focus. *Quarterly Journal of Experimental Psychology* **54A,** 1143–54.

Wulf G., McConnel N., Gärtner M. & Schwarz A. (2002) Enhancing the learning of sport skills through external-focus feedback. *Journal of Motor Behavior* **34,** 171–82.

Wulf G., Weigelt M., Poulter D. R. & McNevin N. H. (2003) Attentional focus on supra-postural tasks affects balance learning. *Quarterly Journal of Experimental Psychology* **56,** 1191–211.

Wulf G., Landers M., Lewthwaite R. & Töllner T. (2009) External focus instructions reduce postural instability in individuals with Parkinson disease. *Physical Therapy* **89,** 162–8.

Wulf G., Chiviacowsky S., Schiller E. & Ávila L. T. (2010a) Frequent external-focus feedback enhances learning. *Frontiers in Psychology* **1,** 190.

Wulf G., Dufek J. S., Lozano L. & Pettigrew C. (2010b) Increased jump height and reduced EMG activity with an external focus of attention. *Human Movement Science* **49,** 440–8.

Zachry T., Wulf G., Mercer J. & Bezodis N. (2005) Increased movement accuracy and reduced EMG activity as the result of adopting an external focus of attention. *Brain Research Bulletin* **67,** 304–9.

Accepted 20 March 2012