Comparative Analysis of fundamental motor skills in Finnish children with and without intellectual disability –A replication study

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Abstract

Children with intellectual disability (ID) characteristically have motor problems. The purpose of this study was to compare differences in motor skills between Finnish children with and without ID, to compare the differences between children with ID with and without DS, and to systematically replicate Rintala & Loovis (2013). Twenty-five Finnish children (10 girls, 15 boys; M age = 8.7 yr.; SD 1.2) with ID were tested using the TGMD-3. Children with ID (including six children with DS) were matched according to age and gender with typically developing children in order to identify differences in motor skills. The findings revealed significant variability in the motor skills of children with ID as was seen in Rintala and Loovis (2013). The differences in the present study were more significant. Differences between children with ID with and without DS were also noteworthy. With the exception of gallop and catch, all remaining motor skills produced no significant difference in performance between children with DS and children with ID without DS. Overall, the lack of adequate motor skill development in individuals with ID may in the future be a further hindrance to their participation in physical activities and maintenance of active lifestyles for optimal health.

***Key words**: Locomotor skills, Ball skills, TGMD-3, Down syndrome*

Introduction

Motor skills are the functions that people need for moving around in their environments and/or for manipulating tools (Gabbard, 2004; Gallahue & Ozmun, 2002; Henderson, Sugden, & Barnett, 2007). Motor skills are divided typically into balance-, locomotor-, and object control skills (Gallahue & Ozmun, 2002). Motor skills evolve together with knowledge processes, for example, sensory perceptions, thinking, and memory (Gallahue & Ozmun, 2002). Previously learned skills influence the learning of new skills (transfer effect). The development of motor skills in children is strongly influenced by interest in and attention to the environment (Gabbard, 2004). However, motor development in children is unique, and the acquisition of motor skills can be challenging or delayed (Gallahue & Ozmun, 2002) as in children with intellectual disability (ID).

Developmental disability affects many areas of reasoning and understanding (Centers for Disease Control and Prevention, 2020). It likewise affects motor development (Rintala & Loovis, 2013). Children with ID face challenges such as control of their own power, body awareness, and motor planning that makes it difficult to learn new motor skills (Cavanaugh, 2017). If a child with ID recognizes that their skills are deficient in relation to same age peers, it may lower the motivation for exercise and it may negatively influence learning. Awareness of poorly developed skills may also reduce the child's self-esteem and self-image (Skinner & Piek, 2001).

According to extant literature, children with ID have substantial delays in the development of motor skills compared to their typically developing peers (Hartman, Houwen, Scherder, & Visscher, 2010; Holfelder & Schott, 2015; Smits-Engelsman & Hill, 2012; Vuijk, Hartman, Scherder, & Visscher, 2010; Westendorp, Houwen, Hartman, & Visscher, 2011b; Zikl, Holoubkova, Karaskova, & Veselikova, 2013). These studies revealed that the level of motor skills and cognitive abilities have been linked in children with ID (Vuijk et al., 2010), since both functions are supported by the same central nervous system structures and components (Hillman, Erickson, & Kramer, 2008). Motor skill deficits may cause difficulties learning (Westendorp, Hartman,

Houwen, Smith, & Visscher, 2011a), performing (Dolva, Coster, & Lilja, 2004), and effecting executive functioning (Hartman et al., 2010). In fact, previous studies demonstrated that there are positive influences between versatile physical activity training and motor skill development in children with ID (Golubović, Maksimović, Golubović, & Glumbić, 2011; Giagazoglou et al., 2013). More specifically, participation in organized sport supported improvement of ball skills (Westendorp et al., 2011b).

Therefore, the evaluation of and continuous research on motor development of children with ID is defensible. Various assessment methods can be used to identify fluctuations, constraints, and potential needs related to children's motor development (Gallahue & Ozmun, 2002). With valid and reliable assessment, movement professionals are able to plan appropriate interventions for individuals with ID that have been confirmed in several meta-analyses to produce positive outcomes in skill related physical fitness (Jeng, Chang, Liu, Hou, & Lin, 2017), to increase physical activity (McGarty, Downs, Melville, & Harris, 2018), and to improve fundamental motor skills (Maïano, Hue, & April, 2018). Consistent with the need to complete field-based research with small samples, replications are important to affirm the development of a formidable database, one that demonstrates reliable and robust findings. Therefore, the primary purpose of this study was to expand the existential database on differences in the development of fundamental motor skills between children with and without ID. A second purpose was to determine if differences exist between children with ID and children with ID and Down syndrome (DS), as a means to challenge the traditional belief that DS creates a less than homogeneous sample. The third purpose was to perform a near exact replication of Rintala & Loovis (2013) study.

Method

Participants

Participants were 25 Finnish children (10 girls, 15 boys; M age = 8.7 yr.; SD 1.2; range 7–10) with mild to moderate intellectual disabilities from eight elementary schools from central Finland. The ID sample also included a subset of six participants with (DS). Moreover, six children were eliminated from the original sample because they were unable to complete the entire TGMD-3. The intelligence quotients were unavailable, but all participants were currently placed in a class for children with ID as designated by the Finnish educational system. Children with severe intellectual disability were excluded from this study because they were using functional devices for ambulation. A matched sample, by age and sex, of 25 children without ID was taken from another sample (Rintala, Sääkslahti, & Iivonen, 2016). As with the children with ID, these children were also videotaped during administration of the TGMD-3. The typically developing (TD) children had no known disabilities. This study also replicated Rintala and Loovis (2013) study where 20 children (8 girls, 12 boys; M age = 9.5 yr., range 7-11) with mild ID had been tested with the TGMD-2. Participation was voluntary and the children's guardians were asked for written consent for participation in the study.

Instrument

Test of Gross Motor Development 3rd edition (TGMD-3) is an individually administered test for assessing gross motor functioning in children between 3 and 10 years of age, by measuring children's performances on two subtests of gross motor development, locomotor skills and ball skills. Locomotor skills have six items: run, gallop, hop, skip, horizontal jump, and slide. Ball skills consist of seven items: two-hand strike, one-hand strike, stationary dribble, catch, kick, overhand throw, and underhand throw. Each skill is assessed on three to five individual criteria, and each criterion is scored either 1 or 0. Therefore, the number of criteria defined how scores ranged (from 0 to 6, 0 to 8 or 0 to 10 per skill). The highest total raw score for the two subtests is 100 points (Ulrich, 2019).

The TGMD-3 score sheet has been available since 2015 (Ulrich, 2017), and the instrument has previously been used in several international studies to measure the gross motor skills of children with special needs (e.g. Mache & Todd, 2016; Simons & Eyitayo, 2016) which increases the internal reliability of this study. The updated TGMD-3 has been found reliable (Allen, Bredero, Van Damme, Ulrich, & Simons, 2017; Estevan, Molina-Garcia, Queralt, Alvarez, & Castillo, 2017; Maeng, Webster, Pitchford, & Ulrich, 2016; Rintala, Sääkslahti, & Iivonen, 2017; Temple & Foley, 2017).

Procedure

Two of the researchers (physical education teachers) collected the data. They were familiar with the TGMD-3. They had established 80% reliability in scoring with the TGMD-3 author through electronic videos before starting evaluation. Researchers achieved the reliability scores of 94% and 86%. They piloted a procedure with one child belonging to the target group. Subsequently, they discussed and found common interpretation on all criteria associated with each skill.

Data collection was arranged so that testing did not cause major disruptions to either the school schedule or the daily routine of the special education teacher. All testing was done indoors. Participants' parents signed informed consent forms. Children with ID were told about test procedure and what was expected of them before and during the test. Researchers honored a decision by any child to refuse to participate.

Researchers wanted to ensure that the testing situation was uncomplicated. They used images (such as "gallop like a horse") to build positive interaction and a trustworthy atmosphere with the children. The aim of these pedagogical solutions was to promote the best possible performance on the subtests.

Children performed each locomotor and ball skill at least twice. They were given a visual model and a clear verbal instruction so that they saw and heard exactly what was expected of them. Additional demonstrations were given if a child did not seem to understand the task (familiarization protocol). The familiarization protocol was administered using the following steps:

a) Child observed the examiner who modeled the expected performance of each skill while verbally describing how the skill should be performed.
b) Child had an opportunity to ask questions or seek clarification about the skill.
c) Another examiner was positioned next to the child to support and guide their attention to the task when it was modeled for them.
d) Child was able to try out the skill before videotaping - at his own pace. His understanding was secured by observing and engaging in practice trials.
e) The most difficult skills were practiced together with a child (see Table 2 which details those skills having the least mastery achieved).
f) Child was videotaped during two to four attempts; the best performance was analyzed.
g) Between performances positive feedback was given by testers.

Test sessions lasted an average of 40-50 minutes depending on children's attentiveness and cognitive capability. Performances were videotaped for later assessment to improve reliability.

Authors rated independently videotaped performances (832 episodes) of children with ID and discussed discrepancies in their results. Cohen's kappa (Cohen, 1960) for inter-rater reliability for total score was 0.86, indicating uniform agreement (Landis & Koch, 1977). Congruence between researchers was 93 % (locomotor skills 94.6 %, ball skills 91.6 %). The values indicate that evaluations were nearly unanimous.

Statistical analysis

Differences in performance between Finnish children with and without ID on the TGMD–3 were analyzed using the Mann-Whitney U-test in SPSS Statistics 22.0 program. Sample size dictated the use of the nonparametric statistics. Means and standard deviations were calculated to describe the sample. The analysis was conducted on the locomotor and ball skills subtests score. Alpha level of .05 was established for all statistical

analyses. In this study variables were age and gender. Independent variables were subtests of TGMD-3. Effect size was calculated using Cohen's d.

Results

The results revealed that there was significant variability within children with ID in their motor skills, most of it on the slide. There were no gender differences in fundamental motor skill performances, except in run ($p = 0.047$). The results showed also that children with ID (total score 54.0 out of 100) differed significantly ($p < 0.001$) from TD children (total score 77.2 out of 100) whose total score was 42 % better than those with ID. The difference was similar in both locomotor and ball skill subtests. In the group of children with ID the range was considerably larger than the range for children without ID (SD 13.1 and SD 7.9, respectively) (Figure 1).

Children with ID were statistically significantly ($p < 0.05$) different from those children without ID in all motor skills except in run ($p = 0.098$) (Figure 2). Children with ID were most successful in run, slide, and underhand throw and least successful in hop, skip, and stationary dribble (Figure 2.). The results revealed that the wider variability of the results within children with ID in their motor skills was on the slide (SD 2.56).

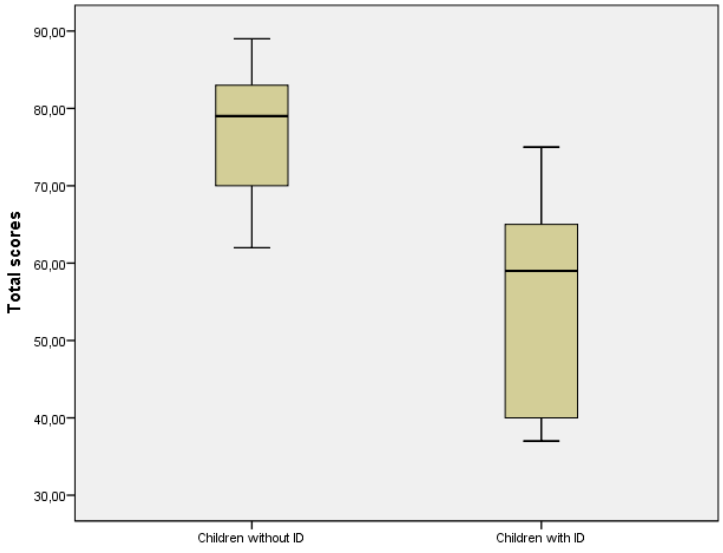

Figure 1. The overall results of TGMD-3 (median, min/max)

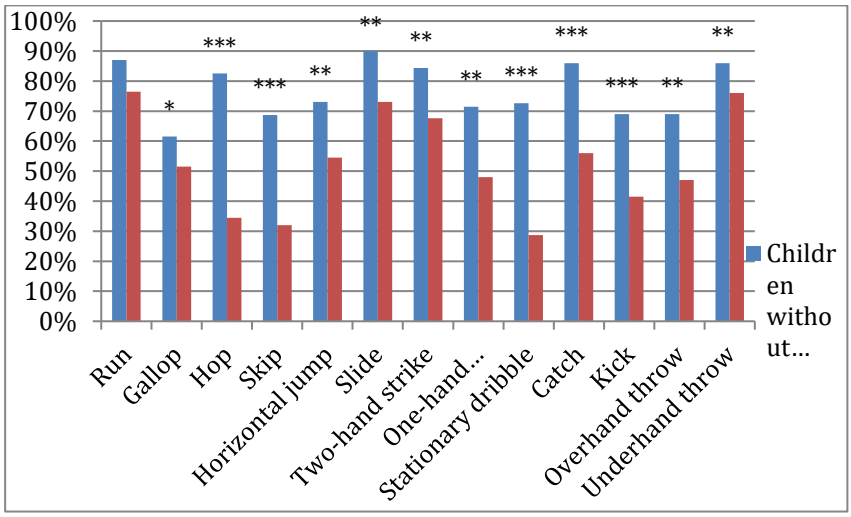

Figure 2. Comparison of the overall results of TGMD-3 by individual skills

When comparing the samples of children with ID with and without DS**, t**he results showed that children with ID (total score 55. 2 out of 100) did not differ significantly (p = 0.445) from children with ID and DS (total score 50.2 out of 100). On only two skills was a statistical difference observed. In the gallop children with DS outperformed children with ID and no DS (p = 0.021). In the catch children with ID and no DS outperformed children with DS (p = 0.035). None of the remaining 11 skills even approached statistical significance. (Table 1).

Table 1. Comparison of students with and without Down Syndrome (DS) on motor skills

Motor skills	Students with DS (n=6)	Students without DS (n=19)	P-value
	Mean (SD)	*Mean (SD)*	
Locomotor subtest	**24.0 (7.5)**	**25.4 (7.6)**	**0.675**
Run	5.3 (1.9)	6.4 (2.0)	0.141
Gallop	4.8 (0.6)	3.9 (1.0)	0.021*
Hop	3.0 (3.3)	2.7 (2.2)	0.981
Skip	0.1 (1.6)	2.3 (2.5)	0.164
Horizontal jump	4.8 (1.8)	4.2 (2.1)	0.783
Slide	*5.3 (2.8)*	6.0 (2.2)	0.609
Ball skills subtest	**26.2 (6.9)**	**29.7 (9.0)**	**0.266**
Two-hand strike	6.3 (2.3)	6.9 (2.6)	0.623
One-hand strike	3.0 (1.8)	4.1 (2.7)	0.369
Stationary dribble	2.0 (2.4)	1.6 (1.7)	0.890
Catch	2.0 (1.3)	3.8 (1.8)	0.035*
Kick	3.3 (2.7)	3.3 (1.6)	0.826
Overhand throw	3.5 (1.2)	3.8 (2.4)	0.963
Underhand throw	6.0 (1.4)	6.1(1.5)	0.799
TOTAL SUM SCORE	50.2 (12.4)	55.2 (13.4)	0.445

*Significance at 0.05 level

When comparing the overall skill performances of two different samples of children with ID (2013 vs. 2017), there was a statistically significant difference in both subtests as well as total sum score (Table 2).

Table 2. Comparative differences in motor skill performances of children with ID between 2013 and 2017 samples

Variable	ID Sample (n=25, 2017)		ID Sample (n=20, 2013)		Mann-Whitney U	*p* (2-tailed)	Cohen´s *d*
	M	SD	M	SD			
Sum total	54.0	13.1	39.7	17.7	150	0.003	0.93
Locomotor skills	25.1	7.5	18.6	11.8	166	0.055	0.68
Ball skills	28.8	8.5	21.1	7.0	120	0.003	0.97

Mastery of the fundamental motor skill is described as achieving '1' on each criterion of the subtest. Table 3 illustrates that mastering skills is difficult for children with ID, for example, none of the participants were able to master gallop, and four other skills were only mastered by one child. On the other hand, thirty-six percent of the children were able to master run. In comparison, children in the current study exceeded the children in 2013 study in seven out of 10 common skills.

Table 3. Mastery on TGMD subtests skills

TGMD-3 skill	ID Group f (%) (n=25, 2017)		ID Group f (%) (n=20, 2013)	
	n	%	n	%
Locomotor subtest				
Run	9	36	4	20
Gallop	0	0	3	15
Hop	1	4	0	0
Skip	3	12	NT[a]	NT[a]
Horizontal jump	1	4	0	0
Slide	8	32	4	20
Ball skills subtest				
Two-hand strike	6	24	0	0
One-hand strike	2	8	NT[a]	NT[a]
Stationary dribble	1	4	2	10
Catch	5	20	4	20
Kick	1	4	1	5
Overhand throw	3	12	1	5
Underhand throw	6	24	NT[a]	NT[a]

[a] Not tested: Subtests not included in TGMD-2

Discussion

Results support the findings from Rintala and Loovis (2013) that motor performance of children with ID is significantly behind same age peers without ID. Participants with ID in the current study had better total scores than children with ID in the 2013 study. Differences between the 2017 and 2013 samples, at least in terms of total scores, could easily be attributable to utilization of an informal familiarization protocol that was employed by the two investigators who collected the data and that is described in the procedure section. The TGMD-3 tasks are not intellectually challenging, but there is always a risk that children with ID might misunderstand the task. In the case of cognitive impairments or attention deficit disorders, this can weaken the reliability of test results thereby underestimating motor ability (Piek, Hands, & Licardi, 2012). Although familiarization protocols such as the one described in the present study are not part of the standardization of the TGMD-3, their use in other testing situations and formats has yielded better estimates of motor proficiency in participants with ID. That is to say, participants demonstrate a better understanding of the task and what is expected of them which appears to translate to improved test performance (Pitetti, Miller, & Loovis, 2017).

Of some concern to those who will read this study is our merging of children with ID with and without Down syndrome (DS). It has been standard practice to eliminate participants with DS because of their poor performance on tests of motor proficiency and physical fitness when compared to those participants with ID without DS. We happen to believe that there is a dearth of comparative data on

the process or qualitative performance aspects of fundamental motor skills and patterns and that the ability of children with DS to do well in tests such as the TGMD-3 are not predicated on having even average motor proficiency or physical fitness. We support this supposition with data from not only our present study but also a recent study by Bouguet (2015). In our current study, roughly one-third of the sample consisted of participants with DS. The Rintala and Loovis study (2013) had no participants with DS. If participants with DS are delayed motorically as the literature would have us believe, then why were the results comparing participants with and without DS so similar.

Moreover, in the case of the Bouguet study (2015), the investigator was attempting to establish concurrent validity between the TGMD-2 and the TGMD-3. She assessed 13 children between the ages of 3 and 7 years. Seven children had DS. Across both tests children with DS outperformed typically developing (TD) children on several locomotor test items including horizontal jump, gallop, and hop on the TGMD-3. They also outperformed TD children on several object control test items including: two-hand strike, kick, and two-hand catch. If DS is such a distinguishing characteristic, then why are the DS participants in these studies performing as well as or in some cases performing better than their TD peers. This would also suggest that participants with ID and DS may be more rather than less similar to their peers with ID without DS.

When considering the extent to which “mastery” (i.e., all criteria are observed) was achieved in the current study versus the 2013 study, there are ambiguous results. Even though participants’ total scores were higher in the current study, this did not necessarily translate into a greater percentage of mastery. The achievement of “mastery” that never exceeded 20% on any item in the 2013 study surpassed that percentage in run, slide, and two-hand strike in the current study. Likewise, there were items in the 2013 study that surpassed the percentage of mastery achieved in the 2017 study, for example, gallop, stationary dribble, kick, and catch.

The difference may be explained by the fact that in the 2017 study participants were given plenty of positive feedback during the tests, regardless of whether their performances resulted in any points scored. Children received feedback that was mainly directed at issues outside of their performance, such as attitude, waiting, instruction compliance, remembering, concentrating and tenacity. The purpose of the feedback was to produce feelings of success and to maintain motivation in the test situation. Another explanation for superior "mastery" scores by the 2017 sample may be related to the use of slow-motion replay in the analysis that made assessment more accurate.

In conclusion, poor motor skill performances of individuals with ID as assessed in this study are remarkable compared to children without ID. Likewise the results are comparatively similar to Rintala and Loovis (2013), albeit the obvious discrepancy in total scores and proportion of mastery achieved even though the sample contained participants with DS. As was stated previously, the traditional sampling strategy has been to exclude participants with DS since they create a non-homogeneous sample. We believe that this strategy is appropriate if the dependent measure is physical fitness or motor proficiency; however, we are not persuaded that the measurement of fundamental motor skills and patterns are necessarily co-variants of these constructs. Given the results of this replication where participants with DS registered similar scores on the TGMD-3 and the Bouguet study discussed previously, it seems incumbent on researchers to make decisions about their samples, i.e., to include participants with and without DS, based on whether or not fitness or motor proficiency factors impact their study. Certainly, we have raised the question regarding the need not to eliminate participants with DS from samples in future studies of fundamental motor skills. What we have confirmed is that individuals with ID are significantly delayed in development of fundamental motor skills. Therefore, interventions designed to promote development of adequate motor skills in individuals with ID with or without DS may help eliminate a major limitation hindering participation in physical activities that promote active lifestyles and optimal health.

References

Allen, K., Bredero, B., Van Damme, T., Ulrich, D., & Simons, J. (2017). Test of Gross Motor Development-3 (TGMD-3) with the use of visual supports for children with Autism Spectrum Di order: Validity and reliability. *Journal of Autism and Developmental Disorders, 47*, 813–833.

Bouquet, J. (2015). Concurrent validity of the TGMD-2 and TGMD-3 in children with Down syndrome. [Honor's thesis, Texas Christian University]. Retrieved from https://repository.tcu.edu/handle/116099117/10287

Cavanaugh, L.K. (2017). Intellectual disabilities. In J.P. Winnick & D.L. Porretta (Eds.). *Adapted Physical Education and Sport* (pp. 153-174). Champaign, IL: Human Kinetics.

Centers for Disease Control and Prevention. (2020). Facts about developmental disabilities. Retrieved from https://www.cdc.gov/ncbddd/developmentaldisabilities/facts.html

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, *20*, 37–46. https://doi.org/10.1177/001316446002000104

Dolva, A.-S., Coster, W., & Lilja, M. (2004). Functional performance in children with Down syndrome. *American Journal of Occupational Therapy*, *58*, 621–629.

Estevan I., Molina-García J., Queralt A., Álvarez O., & Castillo I. (2017). Validity and reliability of the Spanish version of the Test of Gross Motor Development–3. *Journal of Motor Learning and Development*, *5*, 69–81. https://doi.org/10.1123/jmld.2016-0045

Gabbard, C. (2004). *Lifelong motor development*. 4. edition. San Francisco: Cummings.

Gallahue, D., & Ozmun, J. (2002). *Understanding motor development. Infants, children, adolescents, adults.* 5. edition. New York: McGraw-Hill.

Giagazoglou, P., Kokaridas, D., Sidiropoulou, M., Patsiaouras, A., Karra, C., & Neofotistou, K. (2013). Effects of a trampoline exercise intervention on motor performance and balance ability of children with intellectual disabilities. *Research in Developmental Disabilities*, *34*, 2701–2707.

Golubović, Š., Maksimović, J., Golubović, B., & Glumbić, N. (2011). Effects of exercise on physical fitness in children with intellectual disability. *Research in Developmental Disabilities*, *33*, 608–614.

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*, 468–477. https://doi.org/10.1111/j.1365-2788.2010.01284.x

Henderson, S., Sugden, D., & Barnett, A. (2007). *Movement Assessment Battery for Children-2*. 2. edition. London: Harcourt Assessment.
Hillman, C. H., Erickson K. I., & Kramer, A. F. (2008). Be smart, exercise your heart: Exercise effect on brain and cognition. *Nature Reviews Neuroscience*, *9*, 58–65.
Holfelder, B., & Schott, N. (2015). Relationship between motor skill competency and executive function on children with Down's syndrome. *Journal of Intellectual Disability Research*, *59*, 860–872.
Jeng, S-C., Chang, C-W., Liu, W-Y., Hou, Y-J., & Lin, Y-H. (2017). Exercise training on skill-related physical fitness in adolescents with intellectual disability: A systematic review and meta-analysis. *Disability and Health Journal*, *10*, 198-206.
Landis, J., & Koch, G. (1977). The measurement of observer for categorical data. *Biometrics*, *33*, 159–174.
Mache, M.A., & Todd, T.A. (2016). Gross motor skills are related to postural stability and age in children with Autism Spectrum Disorder. *Research in Autism Spectrum Disorders*, *23*, 179–187. https://doi.org/10.1016/j.rasd.2016.01.001
Maeng, H., Webster, E., Pitchford, E., & Ulrich, D. (2016). Inter- and intrarater reliabilities of the Test of Gross Motor Development-Third Edition among experienced TGMD-2 raters. *Adapted Physical Activity Quarterly*, *34*, 442-455. https://doi.org/10.1123/apaq.2016-0026
Maïano, C., Hue, O., & April, J. (2019). Fundamental movement skills in children and adolescents with intellectual disabilities: A systematic review. *Journal of Applied Research in Intellectual Disabilities*, *32*, 1018-1033. https://doi.org/ 10.1111/jar.12606
McGarty, A.M., Downs, S.J., Melville, C.A., & Harris, L. (2018). A systematic review and meta-analysis of interventions to increase physical activity in children and adolescents with intellectual disability. *Journal of Intellectual Disability Research*, *62*, 312-329. https://doi.org/10,1111/jir.12467
Piek, J., Hands, B., & Licardi, M. (2012). Assessment of motor functioning in the preschool period. *Neuropsychology Review*, *22*, 402–413.
Pitetti, K., Miller, R.A., & Loovis, M. (2017). Balance and coordination capacities of male children and adolescents with intellectual disability. *Adapted Physical Activity Quarterly*, *34*, 1–18. https://doi.org/10.1123/APAQ.2016-0010
Rintala, P., & Loovis, E. (2013). Measuring motor skills in Finnish children with intellectual disabilities. *Perceptual and Motor Skills*, *116*, 294–303.
Rintala, P., Sääkslahti, A., & Iivonen, S. (2016). 3–10-vuotiaiden lasten motoriset perustaidot [Fundamental motor skills of 3–10-year-old children]. *Liikunta & Tiede*, *53*(6), 49–55.
Rintala, P., Sääkslahti, A., & Iivonen, S. (2017). Reliability assessment of scores from video-recorded TGMD-3 performances. *Journal of Motor Learning and Development*, *5*, 59–68. https://doi.org/10.1123/jmld.2016-0007
Simons, J., & Eyitayo, G. B. (2016). Aspects of reliability and validity of the TGMD-3 in 7-10 year old children with intellectual disability in Belgium. *European Psychomotricity Journal*, *8*, 3–16.
Skinner, R. A., & Piek, J. P. (2001). Psychosocial implications of poor motor coordination in children and adolescents. *Human Movement Science*, *20*, 73–94.
Smits-Engelsman, B., & Hill, E. (2012). The relationship between motor coordination and intelligence across the IQ range. *Pediatrics*, *130*, 950–956.
Temple, V. A., & Foley J. T. (2017). A peek at the developmental validity of the Test of Gross Motor Development-3. *Journal of Motor Learning and Development*, *5*, 5–10. https://doi.org/10.1123/jmld.2016-0005
Ulrich, D. A. (2017). Introduction to the Special Section: Evaluation of the Psychometric Properties of the TGMD-3. *Journal of Motor Learning and Development*, **5**, 1–4. https://doi.org/10.1123/jmld.2017-0020
Ulrich, D. A. (2019). *Test of Gross Motor Development-3: Examiner's manual.* 3. Edition. Austin, TX: Pro Ed.

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*, 955–965.
Westendorp, M., Hartman, E., Houwen, S. Smith, J., & Visscher, C. (2011a). The relationship between gross motor skills and academic achievement in children with learning disabilities. *Research in Developmental Disabilities*, *32*, 2773–2779.
Westendorp, M., Houwen, S., Hartman, E., & Visscher, C. (2011b). Are gross motor skills and sports participation related in children with intellectual disabilities? *Research in Developmental Disabilities*, *32*, 1147−1153.
Zikl, P., Holoubková, N., Karásková, H., & Veselíková, T. B. (2013). Gross motor skills of children with mild intellectual disabilities. World Academy of Science, Engineering and Technology. *International Journal of Educational and Pedagogical Sciences*, *7*, 1517–1523.