The Motor Skills of Adolescents with Hearing Impairment in a Regular Physical Education Environment

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Abstract

With the exception of balance, adolescents with and without hearing impairment (HI) could have similar motor skills. However, the motor proficiency traits in this age group have not been clearly defined under the same integrated Physical Education (PE) environment. This study compared the gross and fine motor skills of twenty four female adolescents (HI group: n = 7; Hearing group: n = 17; age range: 13 – 15 years) in a regular school. Non-significant difference was found in overall gross and fine motor skills ($p > .05$). However, the HI group scored significantly poorer in kinaesthetic integration than the Hearing group ($p \leq .05$). The findings of this study imply poorer balance abilities of adolescents with HI when compared to their hearing peers. Therefore, structured individualised physical activities focusing on balance development in addition to their regular PE lessons are proposed to improve their balance proficiency for better inclusivity.

Keywords: *disability, inclusive education, special education*

Introduction

Hearing Impairment (HI), also known as hearing loss, refers to the inability to hear normally (Daniel & Lim, 2012). Inevitably, HI has the potential to affect speech and language development due to the challenges associated with receiving and processing auditory information (REF). HI is considered as one of the prevalent congenital disabilities and/or birth defects in Singapore with about 3.7 per 1,000 newborns are diagnosed with HI (Daniel & Lim, 2012). Among those diagnosed with HI, about 1.7 per 1,000 had significant hearing loss (severe – profound; Low, Pang, Ho, Lim, & Joseph, 2005). Without early identification and intervention, these children with HI are at risk of delay in speech and language, intellectual, academic, social and emotional development (Low, 2005; Low et al., 2005).

Studies have reported delayed motor development or poor motor proficiency traits of children and adolescents with HI (Engel-Yeger & Weissman, 2009; Hartman, Houwen & Visscher, 2011; Schlumberger, Narbona, & Manrique, 2004). With the exception of balance, studies have shown that children and adolescents with HI could have similar motor performance for selected motor skills as their hearing peers (Butterfield, 1986, 1987; Brunt & Broadhead, 1982; Dummer, Haubenstricker, & Stewart, 1996).

Stemming from an ecological perspective, Newell's constraints model (1986) could provide an explanation for the motor skill performance of children with HI. Newell (1986) describes how the interaction of individual (e.g. HI), environmental (e.g. physical activity) and task (e.g. one-leg balance) constraints could reciprocally interact with one another to influence psychomotor skills. Delayed psychomotor development as a result of deprived sensory information could be explained by individual constraints such as co-occurring vestibular defects (Schmidt, 1985; Weiss & Phillips, 2006; Wiegersma & Van der Velde, 1983) and/or auditory defects (Hartman et al., 2011; Horak & Macpherson, 1995). Hearing loss is frequently associated with the dysfunction of the vestibular system. This dysfunction of the vestibular system has implications leading to poor balance abilities which could lead to coordination problems and abnormalities in postural control (Horak, Shumway-Cook, Crowe, & Black, 1988; Suarez, Angeli, Suarez, Rosales, Carrera, & Alonso, 2007). This is further supported by Crowe and Horak (1988) who suggested the strong possibility of co-occurrence between vestibular dysfunction (balance) when the auditory (cochlear) mechanism is impaired. Further investigation of the literature suggests that children and adolescents with HI tend to score lower than their hearing peers and/or normative sample on motor test items which require good control of balance (Boyd, 1967; Engel-Yeger, Golz, & Parush, 2004; Livingstone & McPhillips, 2011).

In relation to environmental constraints, studies have shown that a deprived environment may lead to poor physical fitness and less developed motor skills of children and adolescents with HI (Lieberman, Volding, & Winnick, 2004; Polat, 2003). For example, studies have linked poor physical fitness of children and adolescents with HI to obesity and sedentary lifestyles (Dair, Ellis, & Lieberman, 2006; Ellis, Lieberman, Fittipauldi-Wert, & Dummer, 2005; Stewart & Ellis, 2005; Zaccagnini, 2005). Environmental constraints include unstructured Physical Education (PE) curriculum, inadequate instruction time and limited physical activity opportunities rather than individual constraints associated with HI (Butterfield, 1991; Dummer et al., 1996; Gheysen, Loots, & Van Waelvelde, 2008).

The No Child Left Behind Act (Act, 2001) has triggered an increasing worldwide attention and provisions for children with disabilities, including those with HI. Singapore had launched the ComCare Fund to ensure that 'no Singaporean is left behind' (MSF, 2005). Since then, inclusive education has been growing its acceptance in Singapore. The process of integrating or including children with disabilities into Singapore regular schools has continued to receive legislative support. Children and adolescents with HI could either study in special schools for HI or in regular schools. Ho (2007) wrote that the majority of the children with HI could be successfully integrated or included into regular classrooms within the same educational framework as their hearing peers. The integration or inclusion of children and adolescents with HI within regular schools is also higher than other sensory disabilities. It was reported that 502 children with HI compared with 61 children with visual impairment were studying in regular schools (Ministry of Education [MOE], 2002). Although the current statistics are not available, a recent comparison showed a decrease in the number of children with hearing and visual impairments in special schools (Year 2000: 9% of 4,000 students; Year 2010: 3% of 4,800 students; MOE, 2011).

According to Armstrong, Armstrong and Spandagou (2011), inclusive education is epitomised as the ‘Education for All’. In Singapore, the PE vision is “Every Child is Physically Educated” and the PE mission is to develop a curriculum to meet the needs of the nation, community and individual (MOE, 2006). This seems to align with the notion of inclusive education. As more children and adolescents with HI are integrated or included in regular classrooms, the understanding of their motor proficiency traits becomes increasingly necessary for PE planning. The guideline for PE lessons in secondary schools is for all students without medical exclusion to have two 40-minute periods per week, accumulated to at least 29 weeks of two periods per year (MOE, 2006). Within the year, the key PE components include educational gymnastics, dance, games, health and fitness management, track and field and lastly, swimming. While there are international studies investigating the motor or physical domains of children and adolescents with HI (Butterfield, 1987; Dair et al., 2006; Dummer et al., 1996; Gheysen et al., 2008; Horak et al., 1988), comparative information with their hearing peers within the same regular PE setting is limited (Tan, Nonis, & Chow, 2011). Therefore, the aim of this study is to examine the motor skills of adolescents with HI in comparison with their hearing peers who attended similar PE lessons within a regular school.

Method

Participants

Twenty-four female adolescents with and without hearing impairment (age range: 13 – 15 years; HI group: n = 7; M age = 14.71±1.11 years; Hearing group: n = 17; M age = 13.53±0.72 years) were recruited for this study. A secondary school with HI-enabled facilities was identified for recruiting participants with and without HI within the same regular educational environment. The discrepancy in the sample size of HI group and Hearing group is a realistic representation of the HI population in the HI-enabled secondary school. It was reflective of the low incident rate of children with significant hearing loss in Singapore (Low et al., 2005). Voluntary child assents and informed parental consents were obtained together with IRB approval. A health and fitness declaration reply form was completed by every participant to understand their health and medical conditions. Only participants without pre-existing health conditions, recent injury problems and/or motor impairment were included. The HI group had sensorineural hearing loss, ranging from severe to profound (> 70 dB) within the last 12 months of clinical diagnosis prior to the time of testing. The Natural Auditory Oral Approach (NAO) with assistive hearing aids and without sign language was used to communicate with the HI group. All participants attended similar Physical Education (PE) lessons under an integrated setting without additional support given to the HI group. Non-significant differences in the physical activity intensity levels between adolescents with and without HI were reported (p > .05).

Instrument and Tasks

The McCarron Assessment of Neuromuscular Development (MAND) was used in this study (McCarron, 1997). It consists of five fine motor tasks (FM: Bead in Box, Beads on Rod, Finger Tapping, Nut and Bolt & Rod Slide) and five gross motor tasks (GM: Hand Strength, Finger-Nose-Finger, Jumping, Heel-Toe Walk & Standing on One Foot). These are to determine the 1) Neuromuscular Development Index (NDI), 2) Kinaesthetic Integration (KI: Heel-Toe Walk & Standing on One Foot), 3) Muscular Power (MP: Hand Strength &

Jumping), 4) Persistent control (PC: Rod Slide & Finger-Nose-Finger) and 5) Bimanual Dexterity (BD: Beads on Rod & Nut and Bolt). The NDI results refer to the combined factor scores of fine and gross motor skills (FM & GM) which has been used to screen for signs of motor impairments based on the overall proficiency of neuromuscular development of the participants of different countries (Hands, Larkin, & Rose, 2013; McCarron, 1997). The KI results are the combined factor scores of the tasks of "standing on one foot" (SOF) and "heel-toe walking" (HTW) which requires static and dynamic balance abilities respectively. Participants took between 20 to 30 minutes to complete each test session.

Test Procedures and Instructions

Familiarisation sessions were carried out prior to testing. The tests were conducted at a safe indoor environment within the participants' school compound. Standardised verbal instructions and visual demonstrations were provided in accordance to MAND test guidelines. Testing was administered in the same sequence – Bead in Box, Beads on Rod, Finger Tapping, Nut and Bolt, Rod Slide, Hand Strength, Finger-Nose-Finger, Jumping, Heel-Toe Walk and Standing on One Foot as recommended in the manual (McCarron, 1997).

MAND Training for Tester

Prior to the data collection, one tester was trained with reference to the MAND test guidelines (McCarron, 1997). Five out of the 10 MAND tasks involve a combination of qualitative observations and quantitative measurements using the MAND protocol scoring sheet. Administering these five process-oriented tasks thus would require test-retest reliability check. The tester met the recommended MAND test-retest reliability for four of these process-oriented tasks (rod slide: $r = 0.95$, finger-nose-finger: $r = 0.88$, jumping: $r = 0.99$ & heel-toe-walk: $r = 0.94$), with the exception of finger tapping ($r = 0.91$). Nonetheless according to the general reliability coefficient guidelines, reliability coefficients of 0.90 or more were interpreted as excellent test-retest reliability.

Data Reduction and Analysis

The raw scores of the 10 MAND tasks were recorded and scaled scores were computed for respective tasks. Subsequently, these scores were changed into the NDI, FM, GM, KI, MP, PC and BD factor scores according to the age appropriate MAND norm tables (McCarron, 1997). A scale score of ≥ 7 and a factor score of ≥ 85 would be denoted as within the norm range. The dependent variables of MAND Tasks were tested for the assumptions of parametric tests using the Test of Normality and Levene's Test for Equality of Variance. The hypotheses for normal distribution and homogeneity of variances in both tests were rejected ($p > .05$). This indicated that the assumptions of normalised distributed data were not fulfilled and thus the non-parametric Mann-Whitney test was used to test for significant differences in the MAND results between HI group ($n = 7$) and Hearing group ($n = 17$) at $p \leq .05$.

Results

Group analysis of the Neuromuscular Development Index (NDI), Fine Motor (FM) and Gross Motor (GM) results

The results of this study showed that, with the exception of one participant with HI whose NDI was below-norm range (norm ≥ 85), all participants with HI had within-norm NDI results. Statistical analysis using Mann-Whitney test further showed non-significant NDI difference between HI group and Hearing group ($p > .05$; see Table 1). Non-significant differences were shown in NDI, FM and GM results between HI group and Hearing group (NDI: $Z = 0.000$, $p = 1.000$, FM: $Z = 0.000$, $p = 1.000$, GM: $Z = -1.334$, $p = .182$; see Table 1).

Table 1. **NDI, FM and GM Factor Scores Group Results of HI group & Hearing group**

FS	Group	*n*	Mean	*SD*	*Z-score*	*effect size*	*p*
NDI	HI	7	88.3	15.1	0.000	0.000	1.000
	Hearing	17	87.1	17.2			
Fine Motor [FM]	HI	7	94.9	8.6	0.000	0.000	1.000
	Hearing	17	92.6	17.0			
Gross Motor [GM]	HI	7	79.3	13.2	-1.334	0.272	.182
	Hearing	17	82.9	12.7			

Note. *p*-values calculated from Mann-Whitney test for significance differences between HI group and Hearing group at $p \leq .05$.

Group analysis of the Muscular Power (MP), Persistent Control (PC) & Bimanual Dexterity (BD) results

Similarly, non-significant MP, PC and BD differences were also observed between HI group and Hearing group using the Mann-Whitney test (MP: $Z = -0.889$, $p = .374$, PC: $Z = -0.159$, $p = .874$, BD: $Z = -1.524$, $p = .127$; see Table 2).

Table 2. **MP, PC & BD Factor Scores Group Results of HI group & Hearing group**

FS	Grp	*n*	Mean	SD	*Z-score*	*effect size*	*p*
Muscular Power [MP]	HI	7	85.7	20.3	-0.889	0.181	.374
	Hearing	17	78.2	19.2			
Persistent Control [PC]	HI	7	67.9	21.8	-0.159	0.032	.874
	Hearing	17	66.8	21.4			
Bimanual Dexterity [BD]	HI	7	117.1	11.1	-1.524	0.311	.127
	Hearing	17	103.2	22.2			

Note. *p*-values calculated from Mann-Whitney test for significance differences between HI group and Hearing group at $p \leq .05$.

Group analysis and intra-individual analysis of the Kinaesthetic Integration (KI) results

In this section, both group and individual KI results of HI group and Hearing group are reported. In contrast to the non-significant NDI, GM, FM, MP, PC and BD group results, the Mann-Whitney test reported significantly poorer KI result ($p < .05$; see Table 3). Specifically, lower factor scores with moderate effect size were observed in the HI group as compared to the Hearing group (HI group: $M = 78.6$, $SD = 13.8$; Hearing group: $M = 95.6$, $SD = 14.5$ $Z = -2.350$, $p = .019$; see Table 3).

Table 3. **KI Factor Scores Group Results of HI group & Hearing group**

FS	Grp	*n*	Mean	SD	*Z-score*	*effect size*	*p*
Kinaesthetic Integration [KI]	HI	7	78.6	13.8	-2.350	0.480	.019*
	Hearing	17	95.6	14.5			

Note. *p*-values calculated from Mann-Whitney test for significance differences between HI group and Hearing group at $p \leq .05$.

The KI results showed that, with the exception of Participant HF and Participant XY, all participants with HI displayed KI factor scores that were below-norm range compared with the MAND normative sample (norm ≥ 85; see Figure 1). The individual analysis of the two balance tasks which compute the KI results revealed more information regarding the balance abilities of the HI group. Specifically, the group mean scaled scores indicated that the HI group exhibited mild difficulties (norm ≥ 7) in the static balance task of "standing on one foot: SOF" (static balance; M = 6.29, SD = 2.06) and the dynamic balance task of "heel-toe walking: HTW" (dynamic balance; M = 6.14, SD = 4.41). Closer inspection of the individual scaled scores revealed that the percentages of participants with HI who displayed scaled scores within norm range for the tasks of SOF and HTW were 42.9% (3 out of 7) and 57.1% (4 out of 7) respectively (see Figure 2 & 3).

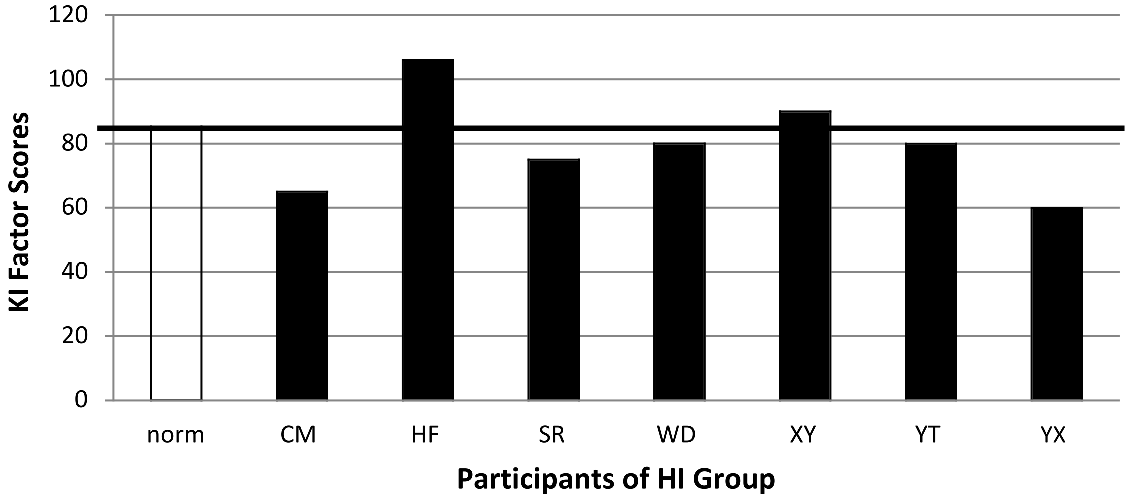

Figure 1. The KI Factor Scores Individual Results (including Standing on One Foot & Heel-Toe Walking).

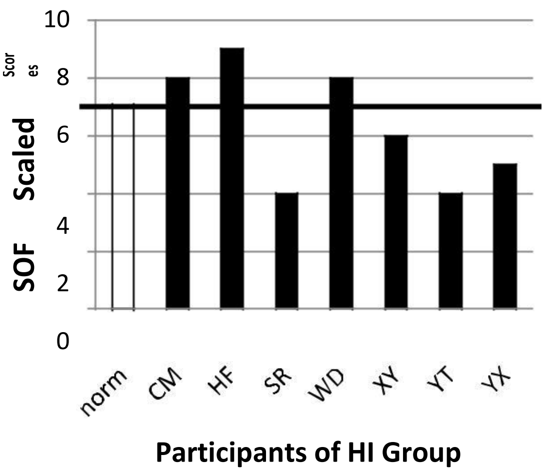

Figure 2. The Standing on One Foot Scaled Scores Individual Results.

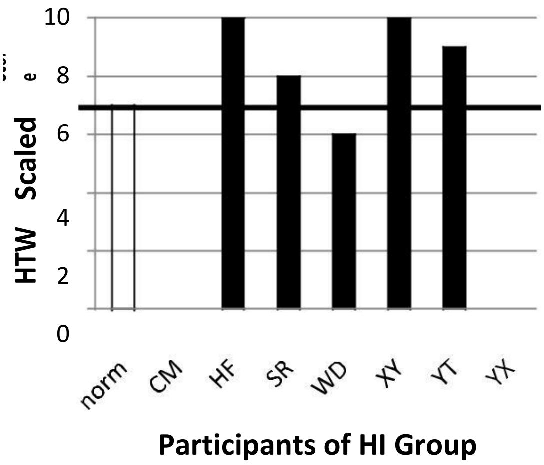

Figure 3. The Heel-To-Walk Scaled Scores Individual Results.

Discussion

The Neuromuscular Development of Adolescents with HI

The non-significant NDI difference (p > .05; see Table 1) between adolescents with HI and their hearing peers in this study has corroborated with most studies investigating on children and adolescents with HI (Engel-Yeger & Weissman, 2009; Gheysen et al., 2008; Schlumberger et al., 2004). To date, using the MAND to compare the motor skills of children and adolescents with HI has not been documented. By comparison, many studies investigating the motor proficiency traits and balance abilities of children and adolescents with HI using other battery tests have been reported (Butterfield, 1986, 1987; Dummer, Haubenstricker, & Stewart, 1996; Engel-Yeger, Golz, & Parush, 2004; Engel-Yeger & Weissman, 2009; Gheysen, Loots, & Van Waelvelde, 2008; Hartman, Houwen, & Visscher, 2011; Lieberman, Volding, & Winnick, 2004; Livingstone & McPhillips, 2011). While Wiegersma and Van der Velde (1983) considered the possibility of HI as the product of neurological defects in their study, none of these studies reported that poorer motor proficiency could be linked to neuromuscular defects (Engel-Yeger et al., 2004; Engel-Yeger & Weissman, 2009; Gheysen et al., 2008; Hartman et al., 2011; Livingstone & McPhillips, 2011).

The Gross Motor Performance of Adolescents with HI

Numerous studies have investigated the gross motor performance of children and adolescents with HI (Boyd, 1967; Brunt & Broadhead, 1982; Butterfield, 1987; Dummer et al., 1996; Lieberman et al., 2004; Lindsey & O'Neal, 1976; Wiegersma & Van der Velde, 1983). Based on the non-significant GM results in this study (p > .05; see Table 1), it is suggested that the gross motor skills performance of the adolescents with HI are not significantly different from their hearing peers. Closer examination of most studies revealed that the children and adolescents with HI scored lower than their hearing peers and/or normative sample on motor test items which require good control of balance (Boyd, 1967; Engel-Yeger et al., 2004; Livingstone & McPhillips, 2011). Some of these gross motor tests included balance test items such as balance on one foot (Brunt & Broadhead, 1982), heel-toe walking or walking on a balance beam (Butterfield, 1986, 1987; Butterfield & Ersing, 1986). Nonetheless, the non-significant GM difference in this study was supported by some other studies which reported comparable gross motor skills between HI and their hearing peers (Brunt & Broadhead, 1982; Butterfield, 1986, 1987; Dummer et al., 1996).

Further analysis of the non-significant GM results pointed out that both HI group and Hearing group showed a group mean of below-norm range (norm $\geq$ 85; see Table 1). In addition, a larger percentage of participants with HI were found to perform at a below-norm range for KI tasks. The GM results are the combined factor scores of gross motor tasks (KI tasks, MP tasks & "finger-nose-finger"). This would suggest that the gross motor proficiency of the participants with HI at below-norm range is more likely to be associated with the significantly poorer KI results compared with their hearing peers. The findings in the current study lend support to other studies which reported that participants with HI scored poorer on motor test items requiring good control of balance (Boyd, 1967; Engel-Yeger et al., 2004; Livingstone & McPhillips, 2011). The findings of this study imply that balance control is critical to the performance of gross motor tasks such as standing on one foot and heel toe walking in the MAND test. These would further suggest that toe walking and balancing on one foot task could be included in their movement programmes to enhance their balance control. However, this plan would have to be investigated further in another research study.

The non-significant GM comparison between HI group and Hearing group in this study suggested that HI as an individual constraint may not be a strong influence on their gross motor skills. Studies have shown that environmental factors such as parenting styles, schooling environment and social perceptions could influence the development of motor skills and proficiencies of motor abilities of children and adolescents with HI (Dummer et al., 1996; Lieberman et al., 2004; Wiegersma & Van der Velde, 1983). However, the findings of this study reported non-significant GM differences as well as non-significant FM, MP, PC and BD results ($p > .05$; see Tables 1 & 2) between adolescents with HI and their hearing peers. This would suggest that the presence of different environmental constraints between them, if any, may not be strong to elicit significant differences. Instead, it could be explained by the fact that both adolescents with HI and their hearing peers were studying in the same regular school and attended similar Physical Education (PE) lessons. Therefore, with the non-significant GM differences between adolescents with HI and their hearing peers ($p > .05$; see Table 1), it could be concluded that neither HI as the individual constraint nor education setting as the environmental constraint pose any significant impact to the gross motor performance of these adolescents with HI in this study.

The Balance Abilities of Adolescents with HI

The HI group had significantly lower KI factor scores than the Hearing group which was also an indication of poorer balance ($p \leq .05$; see Table 3). This finding is supported by many studies which reported that the children and adolescents with HI demonstrated poorer balance abilities when compared to their hearing peers (Boyd, 1967; Engel-Yeger et al., 2004; Engel-Yeger & Weissman, 2009; Schlumberger, Narbona, & Manrique, 2004; Tan, Nonis, & Chow, 2011; Wiegersma & Van der Velde, 1983). Further, this finding is supported in other studies that have reported similar poorer balance abilities in the HI population compared with the normative sample (Brunt & Broadhead, 1982; Hartman et al., 2011; Livingstone & McPhillips, 2011).

While it was suggested that the HI group scored poorer in balance performance than their peers from their significant mean differences, the intra-individual analysis of the KI results were not consistently true that all HI participants had poor balance control. Two out of seven participants scored KI factor scores of within norm range (see Figure 1). Nonetheless, the HI group showed a group mean of below-norm range whereas the Hearing group showed a group mean of norm range respectively (norm $\geq$ 85; see Table 2). Specifically, intra-individual analysis of each participant with HI revealed that with the exception of Participant HF and Participant XY, 71.4% (5 out of 7) of the participants with HI displayed KI factor scores of below-norm range. This finding suggests that five participants with HI demonstrated poorer balance abilities than the MAND normative sample (see Figure 1).

From the group mean scaled scores, the HI group exhibited mild difficulty (below-norm range) for the static balance task of "standing on one foot". In particular, 57.1% of the participants with HI displayed individual scaled scores of below-norm range for "standing on one foot" (see Figure 2). The implication of these findings is that most participants with HI in this study had poorer static balance than the MAND normative sample. This concurs with studies reporting similar poorer proficiency in the ability to balance on one leg when the children and adolescents with HI were compared to their hearing peers (Boyd, 1967; Engel-Yeger et al., 2004). In the dynamic balance task of "heel-toe walking", fewer participants with HI (42.9%; see Figure 3) displayed individual scaled scores of below-norm range. However, similarly, the group mean scaled scores of the HI group were still indicative as having mild difficulty for "heel-toe walking". Many studies also reported poor dynamic balance, coordination and/or reaction time in children and adolescents with HI (Brunt & Broadhead, 1982; Butterfield, 1986; Wiegersma & Van der Velde, 1983).

The group and individual analysis of the KI results showed that the adolescents with HI demonstrated poorer balance than their hearing peers and/or the MAND normative sample. The poorer KI performance of the adolescents with HI observed in this study corroborates with the widely-discussed literature which reported poor balance in the children and adolescents with HI (Engel-Yeger et al. 2004; Hartman et al., 2011; Livingstone & McPhillips, 2011). Based on the findings in this study, this could be due to the poorer static and dynamic balance abilities of the adolescents with HI than their hearing peers.

Using Newell's (1986) constraints model to understand the dynamic nature of individual, task and environmental constraints of the participants with HI in this study, hearing loss and vestibular dysfunction could be linked to their individual constraints. Many studies have highlighted vestibular dysfunction, as the individual constraint, was the main cause of balance deficits (Crowe & Horak, 1988; Suarez, Angeli, Suarez, Rosales, Carrera, & Alonso, 2007). However, the adolescents with HI in this study were not tested for vestibular dysfunction. Instead, the adolescents with HI in this study have sensorineural hearing loss (severe – profound hearing loss). Nonetheless, some studies have stated that the increased risk of vestibular dysfunction because of its association with hearing loss (Horak, Shumway-Cook, Crowe, & Black, 1988; Suarez et al., 2007). Further, it was noted that among the studies reporting significantly poorer balance in their participants with HI, most of these participants with HI have sensorineural hearing loss (Engel-Yeger & Weissman, 2009) or severe to profound hearing loss (Brunt & Broadhead, 1982; Hartman et al., 2011).

While this study suggested that sensorineural hearing loss as the individual constraint to account for the significantly poorer balance of the adolescents with HI, other studies would also consider environmental constraints. Various studies investigating children and adolescents with HI have observed different environmental constraints to account for the differences in motor abilities including balance (Dair, Ellis, & Lieberman, 2006; Gheysen et al., 2008; Wiegersma & Van der Velde, 1983). For example, researchers suggested the inadequate provision of conducive physical environment (Gheysen et al., 2008) and physical inactivity (Dair et al., 2006; Ellis, Lieberman, Fittipauldi-Wert, & Dummer, 2005; Zaccagnini, 2005) as possible environmental constraints. Wiegersma and Van der Velde (1983) also reported negative environmental factors such as frustration, shyness, over-protective and insecurity that deprive the population with HI from regular physical and movement opportunities. However, using different educational setting as environmental constraint to explain the significantly poorer balance abilities of adolescents with HI was not possible since they went through similar PE lessons in the same regular school.

Conclusion

This study investigated if there was a difference in the motor skills between adolescents with HI and their hearing peers in an integrated Physical Education (PE) environment within the same educational setting in Singapore. The ecological perspective of Newell's (1986) constraints model can be used to describe the findings of the current study using the interaction of the individual, task and environmental constraints. The non-significant NDI, FM, GM, MP, PC and BD findings may be attributed to the fact that both adolescents with HI and their hearing peers have similar environmental constraints through attending similar PE lessons to develop their motor skills within a regular school. However, despite being in an integrated PE setting, significantly poorer balance abilities of the adolescents with HI than their hearing peers are observed. While sensorineural hearing loss, as an individual constraint, seems to account for their poorer balance abilities, this study is exploratory in nature without comparison with other types of hearing loss. The explanation of different environmental constraints to explain poorer balance abilities was also not supported in this study and further investigation is warranted.

With the exemplification of inclusive education as the 'Education for All' (Armstrong, Armstrong & Spandagou, 2011) and the PE vision of "Every Child is Physically Educated in Singapore (MOE, 2006), more individualised balance-focused physical activities could be incorporated in students' lifestyles to improve the balance abilities of adolescents with HI as a possible inclusive strategy. For example, this could be considered in the planning of PE curriculum whereby future PE lessons may emphasize on the elements of stability skills. From the repertoire of movements in existing educational gymnastics lessons, this could facilitate the development of balance control. However, the anticipated challenges to cater inclusive PE curriculum for the adolescents with HI would involve the provision for students with various special education needs of different motor abilities. Alternatively, the authors propose an early intervention with an intensive and structured balance programme for the adolescents with HI in addition to their regular PE lessons.

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