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The effectiveness of a fundamental motor skill intervention in pre-schoolers with motor problems depends on gender but not environmental context

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Abstract

This study evaluated the effect of a 10-week fundamental motor skill programme in pre-schoolers with motor problems. Alongside the general effect of the intervention, we also explored possible gender differences and the role of the environmental context (living community, socio-economic status, and recreational space inside/outside the house). The intervention group (n = 47; 20 ♂ and 27 ♀) received twenty 60-min motor skill sessions (2 per week) in addition to the regular physical education curriculum for pre-schoolers; the control group (n = 46; 21 ♂ and 25 ♀) did not receive additional practice. General motor competence, and locomotor and object control subscales, were assessed before and after the intervention using the Test of Gross Motor Development 2nd edition (TGMD-2). Data regarding environmental factors were gathered through a questionnaire. A Group x Gender x Time ANOVA revealed that the intervention group benefited significantly from the intervention and scored better than the control group at the post-test for general motor competence and both sub-categories (locomotor and object control skill). Moreover, the intervention programme was found to be effective in helping 49% of the intervention group to achieve an average motor skill level, according to the TGMD-2 norms, while a further decline in motor competence was observed in the control group. Interestingly, the effect appeared to be gender-specific, since object control skill improved only in girls of the intervention group. Considering the environmental context, none of the above-mentioned factors was found to have an influence on the effectiveness of the intervention. The present study highlights the need for an early motor skill programme with a gender-specific approach in order to help low skilled boys and girls master a diverse set of motor skills.

Introduction

As a precursor for the ability to participate in sports and games, an individual's Fundamental Motor Skills (FMS) competence may be considered a cornerstone for the development of a healthy and active lifestyle and long-term fitness (Barnett, van Beurden, Morgan, Brooks, & Beard, 2008, 2009). These FMS are considered to be the building blocks for complex motor skills, and proficiency in FMS also contributes to successful and satisfying participation in sports and other physical activities. Seefeldt (1980) introduced the term *proficiency barrier*, conceptualizing the notion that a certain level of competence in locomotor and object control skills (i.e., the two categories of FMS) is needed to allow individuals to apply these skills to different sports, games and other lifetime activities (see also Clark and Metcalfe 2002, who refer to *the mountain of motor development*). Locomotor skills involve the movement of the body through space, and include running, hopping, jumping, skipping, galloping, sliding and leaping. Object control skills refer to the manipulation of objects, and include throwing, catching, bouncing, striking, kicking, and rolling (Haywood and Getchell, 2002). It is important to note that FMS competence does not occur naturally, but emerges through interaction of the child with the environment. This interaction is aimed at facilitating exploration of different motor patterns and may include deliberate instruction such as in physical education (Goodway & Branta, 2003; Malina, Bouchard, & Bar-Or, 2004; Thelen & Smith, 1996). Early childhood (approximately from the age 2 to 7) is suggested a period of landmark significance for developing and learning FMS. By the age of seven, an individual is supposed to have expanded its motor repertoire and acquired an adequate level of competence, as it enters a period where children start to engage in sports and games requiring more complex skills (Gabbard, 2008).

The association between proficiency in FMS and different measures of physical activity (PA) has been observed in many cross-sectional studies and it is a common finding that children with poorer FMS are less active (e.g., Bouffard, Watkinson, Thompson, Causgrove Dunn, & Romanow, 1996; Fisher, Reilly, Kelly, Montgomery, Williamson, Paton, & Grant, 2005; Hardy, Reinten-Reynolds, Espinel, Zask, & Okely, 2012; Morgan, Okely, Cliff, Jones, & Baur, 2008; Okely, Booth, & Patterson, 2001; Williams et al., 2008; Robinson et al., 2012). Moreover, recent longitudinal studies have demonstrated that the level of FMS competence in childhood is even a significant predictor of PA levels in later life. For example, Lopes, Rodrigues, Maia, and Malina (2011) found that FMS competence at the age of six, as assessed with the Körperkoordinationstest für Kinder (KTK; Kiphard & Schilling, 1974), significantly predicted the level of PA at the age of ten (see also Barnett et al., 2009). Furthermore, the motor difficulties of children with Developmental Coordination Disorder (DCD) at the age of seven partially explained the lower levels of moderate-to-vigorous PA at the age of twelve (Green, Lingam, Mattocks, Ness, & Edmond, 2011). Rose, Larkin, and Berger (1998) have argued that the lack of FMS competence may cause frustration and difficulty in learning more specialized skills (e.g., rope-jumping, dancing), and therefore reduce the enjoyment of being physically active as well as the likelihood of developing a physically active lifestyle. This notion was later substantiated by Cairney, Hay, Wade, Corna, and Flouris (2005), who found that a lower sense of self-efficacy toward PA partially explains why children with DCD engage less in PA.

In their conceptual model, Stodden et al. (2008) alluded to a *reciprocally and developmentally dynamic relationship* between FMS competence and PA, influenced by related factors, including perceived motor skill competence, physical fitness, and obesity. In addition, Bouffard et al. (1996) showed that low FMS competence at young age (6-9 years) negatively affects the time during which children socially interact with their peers. Clearly, then, it is imperative to monitor skill competence from early childhood onwards, in particular to identify potential delays in motor development or motor deficits. Early and targeted remediation of any motor problem is required to reduce the negative impact on engagement in PA in later life, and also to avoid secondary psycho-social consequences [e.g., distorted self-concept (Majnemer, 1998) and increased anxiety (Schoemaker & Kalverboer, 1994)] or medical conditions [e.g., diabetes (Hannon, Rao, & Arslanian, 2005) and cardiovascular problems (Kavey et al., 2003)].

Against this background, the reduced levels of FMS competence observed in many Western countries further highlight the importance of effective interventions. For instance, in a Flemish study by Vandorpe et al. (2011) using the KTK, a general decline in FMS competence, was observed in 6- to 12-year-olds in comparison with 35 years ago. Specifically, the percentage of children with motor problems had risen from 16% in the original German sample (1974) to 21,1% of the children in the Flemish sample (2011). Similar trends have been reported in other countries, such as Canada (Darrah, Magill-Evans, Volden, Hodge, & Kembhavi, 2007), Australia (Okely & Booth, 2004), Germany (Bös, 2003), and Greece (Kambas et al., 2012). Furthermore, based on repeated assessments in Polish children, it has been suggested that the decline in motor skill competence may be shifting to early childhood (Raczek, 2002), although it should be noted that other studies could not confirm this trend (Eggert, Brandt, Jedtritzki, & Küppers, 2000; Prätorius & Milani, 2004; Rethorst, 2003; Roth et al., 2010). Still, there is general agreement that, given the importance of early childhood (pre-schoolers aged 3 to 7) for motor development, motor skill programmes during this period will reduce the risk of problems in childhood and later on, especially in those children with a developmental delay (see Kirk & Rhodes, 2011; Logan, Robinson, Wilson, & Lucas, 2011).

In response to this notion, a number of researchers have started to document the effectiveness of FMS interventions and the important factors to consider when implementing these interventions in early childhood (e.g., Goodway & Branta, 2003; Valentini & Rudisill, 2004; Zittel & McCubbin, 1996). Based on two recent meta-analyses, the effect size of such interventions was medium to large [Cohen's d = 0.39-0.45 and 2.30-4.76 in Logan et al. (2011) and Kirk & Rhodes (2011), respectively][1]. These reviews further emphasized that an intervention should be underpinned by current motor development theory, tailored to the specific perception and action characteristics of young children, and using a suitable instructional approach. More research is required to determine the best practice (i.e., setting, type of approach, and duration) of motor skill interventions. However, one seems to agree that the school environment is preferred over a home or therapy based setting. Furthermore, an activity-based approach is favoured over direct-instruction (e.g., Apache, 2005) and a mastery motivational climate appears to yield better results compared with a low-autonomy climate (e.g., Robinson & Goodway, 2009). Finally, consistent with guidelines for PA the parental involvement (in providing opportunities and support) is critical.

It is remarkable, however, that despite the wealth of knowledge on correlates of PA and motor competence at different stages of life (Cools et al., 2011; Hardy et al., 2012; Sallis et al., 1999; Venetsanou & Kambas, 2010), research into the role of these factors in FMS intervention is relatively scarce. For example, to our knowledge, only two studies have investigated whether the effectiveness of an FMS intervention may depend on the gender of the child, while previous research has found distinct gender differences during learning various (motor) skills (Garcia, 1994). Apache (2005) found that the effectiveness of a motor skill intervention did not differ between girls and boys, whereas in Goodway and Branta (2003) a greater improvement in object control skill was found in girls vs. boys. This may suggest that girls benefit more from object control practice than boys. Other factors of

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[1] It should be noted that Kirk & Rhodes (2011) primarily focused on interventions for pre-schoolers with a developmental delay, which could explain the substantial variance in effect size.

particular importance for adequate motor development include socio-economic status and level of education of the parents. Children from wealthier backgrounds and those raised by more highly educated parents generally perform better on various motor tests (Cools et al., 2011; Vandendriessche et al., 2012; Venetsanou & Kambas, 2010). In contrast, living in a deprived neighbourhood is considered a risk factor (Goodway, Crowe, & Ward, 2003). Research has also highlighted the significance of available recreational space for FMS development or maintenance (Goodway, Robinson, & Crowe, 2010; Venetsanou & Kambas, 2010). The potential influence of these factors on the effectiveness of motor intervention programmes remains to be investigated, and the purpose of the current study explores their relationship.

This study examines the effect of a ten-week developmentally appropriate and theoretically underpinned FMS intervention on 3- to 5-year-old children with a motor delay and possible gender differences. An important secondary aim of the study was to examine the role of socio-economic status of the household and socio-cultural context in which the child is raised (including the availability of recreational space) on the effectiveness of the intervention. Based on the positive results of earlier interventions [see Logan et al. (2011) and Kirk & Rhodes (2011) for a review on this matter], it was hypothesized that this targeted programme would significantly improve children's motor proficiency, except when the motor delay is the result of an underlying developmental disorder such as DCD. Assuming similar compliance of boys and girls, the effect was expected to be not gender-specific, while the external environmental factors were thought to exert a mediating role on the intervention effect on motor competence. For example, a risk factor such as low socio-economic status of the household, is hypothesized to negatively affect the effect of the intervention. Altogether, we believe that the knowledge that will arise from this study may help practitioners, involved in physical and health education, in designing their health education programmes.

Material and methods

Participants

Four nursery schools were purposively selected, two of which were located in a densely populated city (Antwerp, > 500.000 inhabitants, density: approx. 2500 inhabitants/km^2) and two were located in rural communities (Aartselaar and Ranst, < 20.000 inhabitants, density: approx. 450 inhabitants/km^2). The schools were of similar size with 2-3 classes per grade. All children of the second grade (aged between 3.5 and 5.5 years) attending these schools (N=300) were assessed with the TGMD-2 (see below; Ulrich, 2000). Children scoring at or below the 16th percentile were classed as being at-risk of a motor delay and, hence, eligible to participate in this longitudinal study. This resulted in 93 participants (aged between 3.6 and 5.1 years) or 31% of the initial population, with a gender distribution of 44.1% boys and 55.9% girls (see Figure 1 for a flow diagram). For each participant written informed consent was provided by one of the parents or guardian.

Procedure

Per school 11 to 12 children (depending on the size of the group) were randomly allocated to either the intervention or control group (see Figure 1). The children of the intervention group received a 10-week developmentally appropriate motor programme (on top of the usual PE-curriculum), consisting of two 60-minute sessions per week delivered by a trained PE-teacher (GD or LV) who was assisted by a trainee. To keep the activities and materials standardized across groups, all sessions were carefully selected and prepared by GD and LV prior to delivery. Each session included a broad range of playful activities clustered around 6 themes (i.e., locomotor skills, ball handling skills, jumping skills, postures and balance, play, rhythm and dance), each of which was practiced for approximately 10 minutes. Care was taken to embed all exercises in ecologically valid and playful activities to avoid isolated practice of TGMD-2 test items. Furthermore, to avoid a potential confounding influence of fatigue, all sessions were delivered before lunchtime in an attempt to maximize effectiveness.

The children of the control group continued with their usual programmes, including 2 general PE-classes of approximately 60 minutes per week. At the end of the study (i.e., after the post-test) the 10-week motor programme was delivered to these children too.

Measurements

Motor Competence

Pre and post the ten-week intervention, the child's FMS proficiency was assessed with the Test of Gross Motor Development, Second Edition (TGMD-2; Ulrich, 2000). The test covers 12 test items, subdivided into 6 locomotor and 6 object control skills, and typically takes about 20 minutes to administer. The locomotor skills involve displacement of the centre of gravity from one location to another and include galloping, hopping, leaping, horizontal jumping and sliding. The object control skills involve transport, interception, or projection of objects and include striking a stationary ball, stationary dribbling, catching, kicking, overhand throwing and underhand rolling. Following a visual demonstration, the child was asked to perform the skill twice. To allow correct and reliable measurement the child's performance was recorded on video and scored post-hoc against the criteria prescribed in the manual (3 to 5 criteria to observe per skill) by a trained assessor; the video-recordings allowed a blind assessment. Scores per locomotor or object control subcategory, ranging from 0 to 24, were then summed and converted into a standard score (1-20), which in turn was transformed into a composite standard score or gross motor quotient (GMQ; mean = 100, SD = 15, range = 46-160). Finally, this measure of an individual's overall gross motor ability could also be expressed as a percentile rank.

The psychometric quality of the TGMD-2 is good. Content, concurrent and construct-validity have been established for the general population of children aged 3 to 10 years, including a wide variety of subgroups (Evangelinou et al., 2002; Simons et al., 2008; Ulrich, 2000; Valentini, 2012; Wong & Cheung, 2007). Furthermore, the manual reports a good-to-excellent internal consistency among test items (Cronbach's alpha coefficient for locomotor subtest, object control subtest and gross motor quotient is 0.85, 0.88 and 0.91, respectively), and an excellent test-retest and inter-rater reliability (all *r*-values > 0.85).

All tests were administered in accordance with the guidelines specified in the TGMD-2 manual. The pre-tests took place prior to the 10-week intervention period and post-tests measures were taken 5 weeks after the intervention.

External factors

Prior to the intervention the parent(s) or guardian of the child were asked to complete a questionnaire that provided insight into the child's demographic data and other important environmental factors (see Data Analysis below).

Data Analysis

Measures of general motor competence (or GMQ), locomotor skill, and object control skill were derived from the standard scores and percentile ranks published in the TGMD-2 manual. In addition, gain in GMQ was calculated by subtracting score on the pre-test score from the score on the post-test.

Our method of recruitment allowed classification of the children into an urban and a rural living community group or in other words living in a densely populated area (approx. 2500 inhabitants/km^2) or sparsely populated area (<500 inhabitants/km^2). In addition, the questionnaire served to categorize the sample into different sub-groups based on external factors, including socio-economic status of the household (SES), and available recreational space inside and outside the house. SES was determined using a method proposed by Vandendriessche et al. (2012), which takes into account the occupational status of the parents (unemployed, house-keeping, worker, admin staff, education, self-employed, executive staff, liberal profession), and yields three SES-classes: low, middle, high. Finally, the group was classified into sub-groups having few, average or a lot of playing opportunities based on the reported size of the recreational space inside the house (classified into < 20 m^2, 20-to-50m^2, or > 50m^2) and outside the house (classified into < 10 m^2, 10-to-50m^2, or > 50m^2).

Statistical Analysis

Because categorisation of the sample into different SES classes and sub-groups regarding playing opportunities was performed post-hoc, we first examined whether distributions across these classes or sub-groups were similar for the intervention and control group using common chi-squared tests. Further, the effect of the intervention on motor competence and the potential influence of gender were investigated with repeated measures ANOVAs [within factor: Time (pre, post), between factors: Group (intervention, control) and Gender (male, female)] and Bonferroni post hoc tests. Two separate models were used: one for GMQ and one for the subcategories (i.e., locomotor skills and object control skills). Significant 3-way interaction-effects were further examined with 2-way repeated measures ANOVAs and Bonferroni post hoc tests. In addition, we also examined the effect of the intervention on the distribution of the sample across the GMQ categories as specified in the TGMD-2 manual (i.e., very superior, superior, above average, average, below average, poor, and very poor) with a chi-squared test. Finally, the potential influence of the independent variables (i.e., living community, SES and inside/outside recreational space) on the intervention was investigated by comparing the gain in general motor competence (GMQ) across sub-groups or classes for each independent variable separately. An Independent Sample T-test was used to compare GMQ gain of the urban and rural sub-group. Because sample sizes in the different

SES-classes and sub-groups of inside/outside recreational space were not equal and small, a non-parametric Kruskal-Wallis test was used to evaluate differences in gain for these variables. Values of $p \leq 0.05$ were considered statistically significant and where relevant partial η^2 was reported to indicate effect size.

Results

Participant characteristics

The distribution of the children in the intervention and control group across sub-groups based on the external factors (independent variables: SES, recreational space inside and outside the house) is shown in Table 1. Chi-squared analysis indicated that the distribution of the two groups was similar for each independent variable.

Influence of the intervention on children's motor competence

The pre-test and post-test scores on the TGMD-2 (i.e., GMQ, locomotor and object control skills) are reported in Table 2. In accordance with the primary aim of the study, we will first focus on the general effect of the intervention as shown in Table 3. A significant interaction effect between time and group was found for the GMQ, and for the sub-categories locomotor skills and object control skills (partial η^2 = 0.302, 0.281, and 0.183, respectively). For none of these dependent variables a difference between the intervention and control group was found at baseline (pre-test). After the intervention, GMQ of the intervention group had improved significantly ($p<0.001$), while the GMQ score of the control group tended to decrease over time ($p = 0.009$). Likewise, a positive effect of the intervention was observed for locomotor skills ($p < 0.001$), however no progress was made in object control skills ($p = 0.090$). In the control group, locomotor skills remained stable over time ($p = 0.988$), while the performance on object control skills decreased ($p < 0.001$). After the intervention, the intervention group scored significantly better than the control group on GMQ and each of the sub-categories.

The effect of the intervention on the children's motor proficiency was further examined by exploring the change in GMQ rating. At baseline, the children of the intervention and control group were equally distributed across the 'very poor', 'poor', and 'below average' category (on average 34%, 54%, and 12%, respectively; χ^2=1.705; p=0.426). After the intervention, however, a difference between the two groups was found (χ^2=24.080; p<0.001). Eighty percent of the children in the control group were diagnosed with a 'very poor' (35%) or 'poor' (45%) motor quotient in contrast with 30% in the intervention group. Furthermore, GMQ ratings of 43% of the children in the intervention group had improved to 'average', which was the case for only 3% of the control group. Finally, it is remarkable that, on the post-test, the number of children with 'very poor' motor competence more than doubled in comparison with the pre-test in the control group (15.2% vs. 35%), whereas the size of this sub-group did not change substantially in the intervention group (9% vs. 11%).

Influence of gender

The significant gender x time x group interaction effect (shown in Table 3) indicated a modulatory role of gender on the time x group interaction for GMQ and object control skills described above. Other significant interaction or main effects involving gender remained absent. The three-way interaction effects were further examined with secondary repeated measures ANOVA (time x group for boys and girls separately), of which the results are presented in Table 4.

It appeared that the intervention had a significant (positive) effect on GMQ of the girls in the intervention group (partial η^2 = 0.587), while for the boys there was a trend toward significance (see time x group interaction in Table 4 and Figure 3). Girls in the intervention group had improved significantly ($p = 0.004$) while the GMQ score of the girls in the control group decreased over time ($p < 0.001$). There were no effects of time on the GMQ of the boys in either the intervention or control group. Although no difference in GMQ was found at baseline, both girls and boys in the intervention group scored better than their control counterparts after the intervention ($p < 0.001$ and $p = 0.017$, respectively).

Likewise, there was only a significant time by group interaction effect in girls for object control skills (partial $\eta^2 = 0.472$) (see Figure 4). Object control skills of the girls from the intervention group improved significantly ($p=0.004$) while the score of girls from the control group decreased over time ($p<0.001$; see Figure 3). Furthermore, in view of comparable object control scores at baseline ($p = 0.896$), girls in the intervention group scored significantly better than girls in the control group after the intervention.

Influence of external factors

The gain scores within the intervention group on motor competence (GMQ) for the different sub-groups of each external factor (i.e., living community, SES of the household, and recreational space inside/outside the house) as well as the results of the analysis (i.e., Independent Sample T-test or Kruskal-Wallis test) are reported in Table 5. For living community, no significant difference in GMQ gain score was found between children living in an urban or rural area. Analysis on SES of the household also showed no significant differences in GMQ gain score between low, middle and high SES. Likewise, no significant differences were found for recreational space inside and outside the house.

Discussion

In this study we examined the effect of a targeted intervention in FMS (locomotor and object control skills) of pre-school children with poor motor competence and possible gender differences. It was scrutinized whether a 10-week targeted motor intervention programme can prevent a further decline in motor competence in preschoolers with low FMS and even help these children achieve the same level as their normally developing peers. Secondly, in view of the impact of environmental context on motor development (Cools et al. 2011;

Vandendriessche et al., 2012; Venetsanou & Kambas, 2010), we investigated the role of living community, SES and availability of space, on the effectiveness of the intervention.

We found that the motor programme significantly improved FMS of the children in the intervention group; they scored substantially better on general motor competence (GMQ), locomotor skills and object control skills than the control group five weeks post-intervention. The partial η^2 –values indicate a large intervention effect [all partial $\eta^2 > 0.14$; see Cohen (1988)], which is in a similar range of those reported in a meta-analysis of 11 studies published by Kirk and Rhodes (2011). Based on the TGMD-2 norm tables, motor competence of 43% of the intervention group had changed from ‘below average’, ‘poor’, or ‘very poor’ to ‘average’ (vs. only 3% of the control group). When these results are translated to percentile ranks, which were used to identify children with motor difficulties, nearly half (49%) of the intervention group scored above the 16th percentile after the intervention (vs. 5% of the control group). Consistent with previous research (Apache, 2005; Goodway & Branta, 2003; Goodway et al., 2003; Robinson & Goodway, 2009), it thus seems that the intervention was effective for a large proportion of the children especially since the post-test took place five weeks after the intervention had finished. Moreover, the results indicate that children are at risk for a further decline in FMS competence when no intervention is provided. The long retention interval may have washed out any intervention effects in other children, which might suggest that they need a longer intervention programme for a more permanent change in FMS competence. Alternatively, these findings highlight that part of the children may require a more individualized approach or have more pervasive developmental disorders. For example, deviant and less efficient behaviour in both locomotor and object control skills have been observed in children with Developmental Coordination Disorder (DCD), despite long therapeutic interventions (Deconinck et al., 2006a, 2006b).

Interestingly, the advantage of the intervention appeared to be gender-specific. Boys and girls showed a similar gain in locomotor skills, but only the girls' object controls skills benefited from the 10-week practice. Some studies have shown that gender differences in object control skills (with boys performing better than girls) are already present in early childhood (Goodway et al., 2010; Lorson & Goodway, 2008; Thomas & French, 1985), which may have given the girls in the intervention group a greater potential to improve their FMS competence. Indeed, at baseline a significant difference was found between boys' and girls' raw scores for object control in the current study (12.05 ± 4.80 vs. 7.90 ± 3.49), however this difference was not present when scores were converted to the gender-specific standard scores. A difference in object control skill at baseline thus seems not to be a valid explanation for the greater gains in girls and/or the lack of improvement in boys. Perhaps the reason for this difference then is related to the delivery of the practice, and the fact that boys engage more in object control related games and activities during free play than girls (Garcia et al., 1994; Hardy et al., 2012). Accordingly, the object control activities provided during the intervention might have been more challenging for the girls because they had little experience with similar activities outside the intervention. As a consequence, teacher instruction may have been more directed towards the girls, so that the ultimate benefit was larger than for boys. Unfortunately, at present no data are available to measure these factors, though the finding that object control skills of girls in the control group further declined in the absence of a targeted intervention, while those of boys remained virtually unchanged, may partly support this notion. Furthermore, Garcia (1994) found distinct interaction patterns between boys and girls in the context of learning FMS, with boys being more competitive and individualized and girls being more cooperative and caring. In view of these observations and considering the difference in effect of intervention on boys and girls in the present study, future research should aim to determine optimal object control activities and instructional approaches for each gender.

As motor development is socially and environmentally embedded, we also analysed the influence of external factors (i.e., SES, living community, inside/outside recreational space) on the gain in GMQ, within the intervention group. Previous studies have shown that SES is related to motor performance, in which children with high SES scored better than children with low SES (Pratörius & Milani, 2004; Vandendriessche et al., 2012). Furthermore, the recreational space inside and outside the house are also suggested to be relevant factors as they provide children the opportunity to develop their FMS (Goodway et al., 2010; Venetsanou & Kambas, 2010). In relation to this, a study of Loucaides, Chedzoy & Bennet (2004) showed that parents from rural communities report more recreational space outside the house than parents from urban living area. In the current study we did not find significant effects of these factors on the gain in GMQ due to the intervention. This suggests that SES, living community and the availability of playing space do not mediate the effect of the intervention, despite their known influence on motor competence in general. Still, it should be acknowledged that this study specifically targeted children with low FMS competence. In addition, sample sizes were rather small, and the distribution across categories within the intervention group was unequal for most of the majority of these factors, so future research is needed to identify potential mediators of motor skill interventions in more detail.

In addition to the relatively small sample sizes mentioned above, some minor limitations must be taken into account as well when interpreting the results of our study. First, information concerning height or weight of the participants was not obtained so that the role of growth or weight status on the intervention effects could not be examined. Second, participants were not screened for possible developmental disabilities or medical conditions (neurological or neuromuscular), making it impossible to determine whether the intervention is suited for the needs of this population. Finally, post-tests were taken five weeks after the intervention, which prevented a clear evaluation of short-term intervention effects. Further research is needed to determine which key factors are important to successfully implement a motor skill intervention and which alterations are due to meet the demands of each.

In summary, a 10-week FMS intervention programme was demonstrated to be effective in improving the general FMS competence of low skilled pre-schoolers and successful in helping nearly half of these children to achieve an average level of competence. Also, the present study showed a further decline in FMS competence when no intervention is provided, which implies early motor skill programmes are necessary to prevent a negative downward spiral of motor competence. Nonetheless, when considering the object control skills, only girls seem to benefit from the intervention programme, suggesting the need for a gender-specific approach in learning and developing FMS, specifically object control skills. The role of the environmental context in the effectiveness of the intervention was found not to be significant, but further investigation on a larger scale is required. Our study certainly highlights the need for an early motor skill programme with a gender-specific approach in order to help these low skilled children master a diverse set of motor skills and to enable future participation in PA, games and sports.

Acknowledgments

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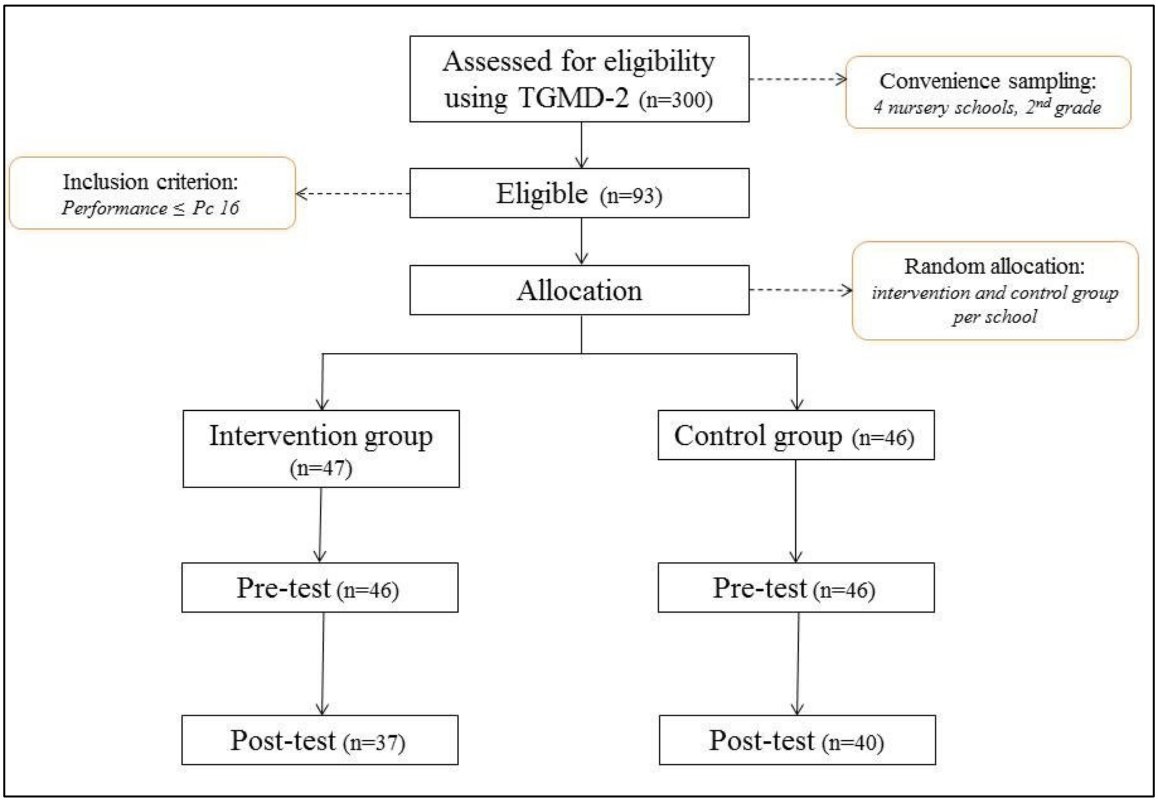

Figure 1: Flow chart of the selection and randomization procedure for the study.

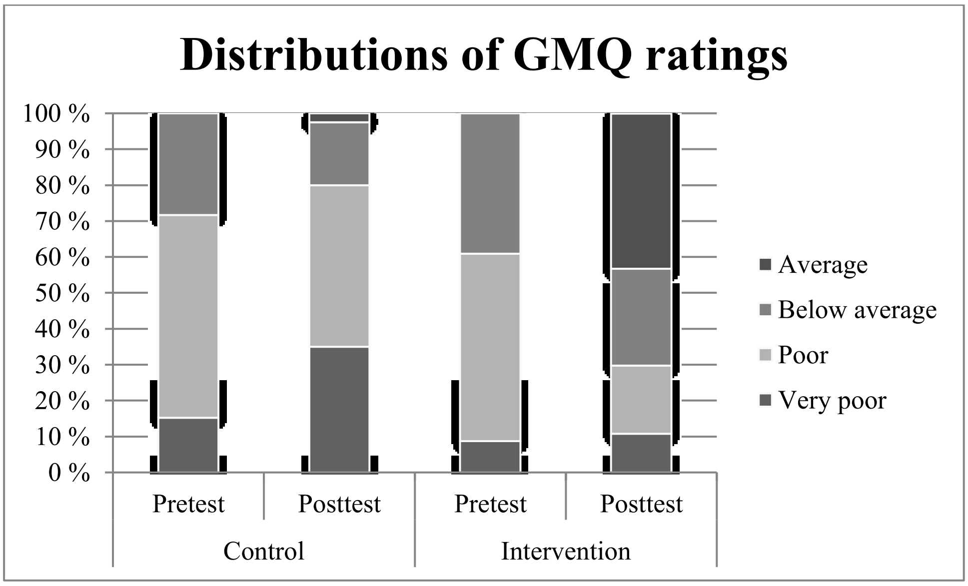

Figure 2: Distributions of GMQ ratings by Group.

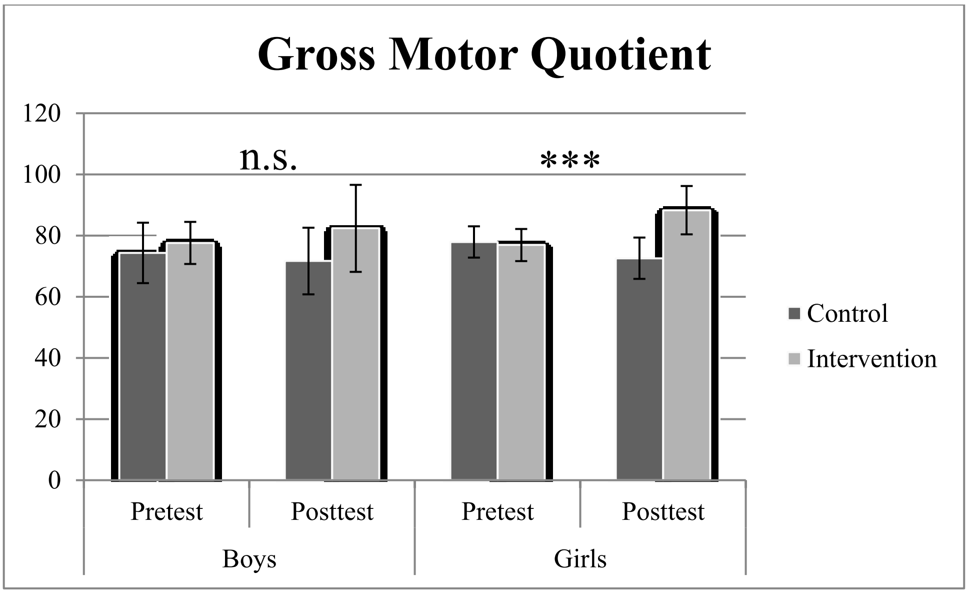

Figure 3: Gross Motor Quotient by Group and Gender.

*[n.s., not significant (p > 0.05) ***p < 0.001]*

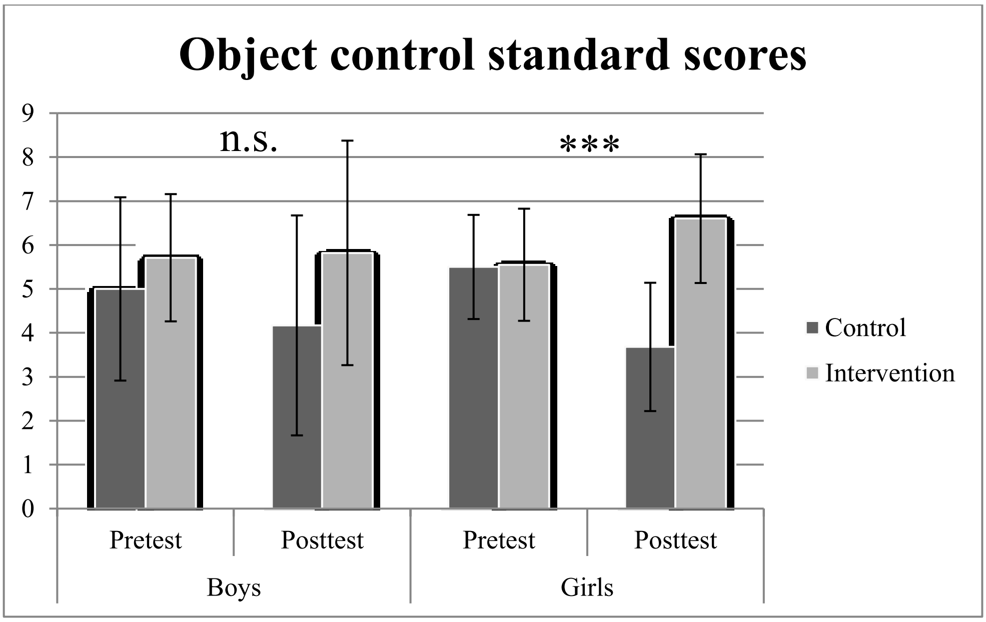

Figure 4: Standard scores for Object Control by Group and Gender.

*[n.s., not significant (p > 0.5) ***p < 0.001]*

Table 1: Distribution of the intervention and control group across sub-groups based on external factors and results of the Chi squared analysis.

Factor		**Group** Intervention (%)	Control (%)	χ^2	P
SES	Low	13.2	12.5	1.236	0.539
	Middle	63.2	52.5		
	High	23.7	35.0		
Recreational space inside the house	< 20m²	23.1	25	0.646	0.724
	20m² - 50m²	38.5	45		
	> 50m²	38.5	30		
Recreational space outside the house	< 10m²	17.9	14.6	0.777	0.78
	10m² - 50m²	23.1	31.7		
	> 50m²	59.0	53.7		

Note. SES = socio-economic status of the household

Table 2: Means (M) and standard deviations (SD) of performance on the TGMD-2 (standard scores and percentile ranks) for the intervention and control group. Gross motor quotient (GMQ) and performance in sub-category locomotor and object control skills are shown separately.

		Standard Score				Percentile			
		Pre-test		Post-test		Pre-test		Post-test	
Variable	**Group**	**M**	**SD**	**M**	**SD**	**M**	**SD**	**M**	**SD**
GMQ	Intervention	77.22	5.98	85.57	11.49	7.78	4.93	22.30	17.24
	Control	76.30	7.74	72.18	8.75	7.23	4.08	5.05	6.43
Locomotor	Intervention	6.78	1.65	8.95	2.35	17.27	12.66	39.97	22.49
	Control	6.83	1.80	6.83	1.99	18.08	12.00	18.85	15.95
Object control	Intervention	5.62	1.34	6.24	2.05	9.19	7.93	14.86	12.30
	Control	5.28	1.65	3.90	1.99	8.05	7.24	4.75	10.27

Table 3: Results of the repeated measures (M)ANOVA for Locomotor and Object Control Standard Scores, and Gross Motor Quotient (GMQ).

	3-Way Interaction Effect		**2-Way Interaction Effect**				**Main Effect**					
	Time x Group x Gender		**Time x Group**		**Time x Gender**		**Time**		**Group**		**Gender**	
Variable	**F**	**p**	**F**	**p**	**F**	**p**	**F**	**p**	**F**	**p**	**F**	**p**
GMQ	4.663	**0.034**	31.531	**<0.001**	0.858	0.357	3.618	0.061	18.585	**<0.001**	2.158	0.146
Locomotor	1.579	0.213	20.357	**<0.001**	2.167	0.145	20.163	**<0.001**	7.761	**0.007**	2.991	0.088
Object Control	4.119	**0.046**	16.343	**<0.001**	0.003	0.956	2.647	0.121	15.984	**<0.001**	0.227	0.635

Table 4: Results of the repeated measures ANOVA for Object Control Standard Scores, and Gross Motor Quotient (GMQ) within gender.

		Interaction Effect		**Main Effect**			
		Time x Group		**Time**		**Group**	
Variable	**Gender**	**F**	**p**	**F**	**p**	**F**	**p**
GMQ	Boys	3.644	0.065	0.29	0.594	5.107	**0.031**
	Girls	56.812	**<0.001**	7.519	**0.009**	20.69	**<0.001**
Object Control	Boys	1.218	0.278	0.69	0.412	3.81	0.059
	Girls	35.826	**<0.001**	2.57	0.117	18.853	**<0.001**

Table 5: Means (M) and standard deviations (SD) of gain in GMQ for the sub-groups of each external factor, and the results of the Independent Sample T-test (for living community) and Kruskal-Wallis test (for SES and recreational space inside/outside the house).

			Gain GMQ			
Factor		**N**	M	SD	**t/H**	**p**
Living community	Urban	14	10,00	8,55	0,886	0,382
	Rural	15	6,79	12,92		
SES	Low	3	5,25	9,61	1,170	0,557
	Middle	19	10,11	10,40		
	High	7	11,57	11,41		
Recreational space inside the house	< 20m²	8	9,38	14,65	2,010	0,366
	20m² - 50m²	10	6,00	10,78		
	> 50m²	11	12,82	8,17		
Recreational space outside the house	< 10m²	3	2,40	12,62	2,207	0,332
	10m² - 50m²	9	12,67	9,81		
	> 50m²	17	9,53	11,09		

Note. Gain = (post-test score) - (pre-test score)

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