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The Effects of a Power-Assisted Exercise Intervention on Alertness in People With Profound Intellectual and Multiple Disabilities

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One of the benefits of physical activity in people with profound intellectual and multiple disabilities (PIMD) is an increase in alertness. This study investigated the effect of a power-assisted exercise intervention on alertness and the relationship of this effect to the level of additional motor and visual impairments in people with PIMD. A randomized controlled trial design ($N = 37$) was used with five measurements. Using individual plots and multilevel analysis, differences in change of alertness over time were analyzed between the intervention and control group, as was the relationship of changes to additional impairments. Considerable variation in alertness over time was found. The results showed no difference between the control and intervention groups in terms of alertness. No relationship with additional impairments was found. This study underlines the importance of looking at the effectiveness of interventions for people with PIMD because those interventions may not be as effective as expected.

Keywords: alertness; motor activation; profound intellectual and multiple disabilities; randomized controlled trial

People with an intellectual disability are at risk of being physically inactive, and this risk increases when the disabilities are more severe (Emerson, 2005; Robertson et al., 2000). A specific subset of this group is people with profound intellectual and multiple disabilities (PIMD). According to Nakken and Vlaskamp (2007), this group consists of people who have both a profound intellectual disability and a severe or profound motor disability. Furthermore, they have several medical complications and sensory impairments such as visual and auditory impairments (van Timmeren et al., 2017). These people are completely dependent on others in everyday tasks in all aspects of daily life (Nakken & Vlaskamp, 2007) and thus require the assistance of others to be physically active.

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Motor activation has multiple benefits for people with PIMD, one of which is an increase in alertness (Cuvo, May, & Post, 2001; Guess, Roberts, Siegel-Causey, & Rues, 1995; Lancioni, O'Reilly, & Mantini, 1999). For people with PIMD, alertness is described as the level of being open to the environment (Munde, Vlaskamp, Ruijssenaars, & Nakken, 2011). According to Munde, Vlaskamp, Ruijssenaars, and Nakken (2009), alertness is crucially important for their personal development and increases their learning opportunities. Several studies have noted the effect stimulation in the environment (i.e., visual and auditory stimuli) has on alertness in people with PIMD (Jones et al., 2007; Munde et al., 2012). Moreover, motor activation can increase alertness: Changing position gives people with PIMD the opportunity to experience the environment differently and may thus increase their ability to explore the environment.

Despite the benefits motor activation has on alertness, people with PIMD are rarely activated. Van der Putten, Bossink, Frans, Houwen, and Vlaskamp (2017) studied the motor activation of 58 people with PIMD in four care institutions on 14 days over a 4-week period. Results showed that, on average, 52% of the participants were offered less than one motor activity per weekday, whereas 7% of the participants did not engage in any motor activities at all during the 14 weekdays of observation. One reason for this motor inactivity may be the lack of evidence-based interventions. In a review about the effects of motor interventions in people with profound intellectual disabilities, none of the interventions was studied in a randomized controlled trial for people with PIMD (Houwen, van der Putten, & Vlaskamp, 2014).

To increase the effective support of people with PIMD in the motor domain, several initiatives have been developed in practice, but scientific evidence about their effectiveness is lacking. One initiative that is used to support people with PIMD is an adaptation of the power-assisted exercise intervention, which was developed for elderly people. This intervention involves machines that incorporate concentric contractions that can be adjusted to a person's abilities. The intervention has already been proven effective for elderly adults, yielding significant improvements in muscle endurance, balance, and functional capacity during a 12-week training period (Jacobson, Smith, Fronterhouse, Kline, & Boolani, 2012).

A first study showed that the adaptation of the power-assisted exercise intervention is feasible and acceptable to people with PIMD living in a residential facility (Bossink, van der Putten, Waninge, & Vlaskamp, 2017). This study also suggests that the intervention did not affect alertness after a 20-week period (Bossink et al., 2017), which is not in line with the evidence of the benefits of activation for people with intellectual disabilities (Cuvo et al., 2001; Jones et al., 2007). However, there was a broad range in the change in alertness among the people with PIMD, which is also in line with the large individual differences found for alertness among these people (Munde et al., 2012).

The study by Bossink et al. (2017) did not take into account the individual variability and the additional impairments of people with PIMD, which could explain why it found no significant group effect. For example, in their study about the use of functional movement activities for children with PIMD, van der Putten, Vlaskamp, Reynders, and Nakken (2005) found that children who scored very low on level of motor abilities benefited most from the intervention. Moreover, according to ten Brug, van der Putten, Penne, Maes, and Vlaskamp (2015), the severity of sensory impairments could limit the ability of a person with PIMD to show attentive reaction. As a result, the effect of the power-assisted exercise intervention on alertness may be related to a person's motor and visual impairments. This study presents an in-depth analysis of the effects of the power-assisted exercise intervention on alertness, taking into account the existence and degree of motor and visual impairments (ten Brug et al., 2015; van der Putten et al., 2005).

METHOD

This study was a pilot randomized controlled trial, with five measurements of alertness including a baseline. The intervention was implemented for 20 weeks. Research was approved by the participating facility's institutional review board. The study is also registered in the International Standard Randomized Controlled Trial Number (ISRCTN) registry (reference number: ISRCTN85363315).

Participants

Participants were recruited from one residential facility that intended to implement the power-assisted exercise intervention. This facility offers support to people with an intellectual disability in combination with a visual impairment. Inclusion criteria were based on the description given by Nakken and Vlaskamp (2007), who describe two key characteristics of people with PIMD: (a) profound intellectual disability: a developmental age of 24 months or lower and (b) profound or severe motor impairments: a Level IV or V score on the Gross Motor Function Classification System (GMFCS; Palisano et al., 1997). People were excluded if they had a severe progressive illness or disorder, or if they had recently experienced surgery, had moved to another (residential) facility, or had experienced another fundamental change to their environment (e.g., death of a relative). For every participant, written informed consent to participate in the study was granted from parent(s) or legal representatives.

Randomization of the 37 selected participants was done by allocation using the method of minimization (Birkett, 1985). The following characteristics were taken into account in allocation: GMFCS score, gender, and age. Participants were divided into four age categories: 0–18 years, 19–37 years, 38–57 years, and 58 years and older. The intervention group contained 13 men and 6 women (M age = 30.2, SD = 11.4, range: 13–50 years); the control group contained 12 men and 6 women (M age = 34.1, SD = 17.4, range: 4–60 years). Table 1 shows the distribution of the additional impairments of the participants by group. There were 12 participants (32.4%) with partial visual impairment, and 25 participants (65.6%) were blind. Moreover, 11 participants (29.7%) had a GMFCS Level IV score, and 26 participants (70.3%) had a GMFCS Level V score.

Intervention and Control Condition

The intervention, which consisted of power-assisted exercises for people with PIMD, was an adaptation of a power-assisted exercise intervention for elderly people without intellectual disabilities (Jacobson et al., 2012). Power-assisted exercises such as sit-ups, hip flexion, spreading and closing arms and legs, and moving arms and legs up and down were carried out using six different power-assisted exercise machines that supported the participants in performing the exercises.

TABLE 1. Distribution of the Visual and Motor Impairments of the Participants by Group

	GMFCS Level		Visual Impairment	
Group	IV	V	Partial	Blind
Intervention (n = 19)	5	14	6	13
Control (n = 18)	6	12	6	12

Note. GMFCS = Gross Motor Function Classification System.

The power-assisted exercise intervention was individualized for each participant by a physical therapist with the assistance of a direct support person. Both were familiar with each participant and their physical condition. Each participant in the intervention group participated three times a week for 30 minutes in his or her individual intervention over a 20-week period. All the individual interventions were intensified during the intervention period. The intervention was offered instead of a passive activity (e.g., watching TV or listening to music). The control group participated in the regular program (Vlaskamp, Hiemstra, Wiersma, & Zijlstra, 2007).

Outcome and Measurement

Alertness was measured using the Alertness Observation List (Munde et al., 2011). With this instrument, an individual alertness profile for each participant was compiled in close consultation with their direct support people. The profile describes individual behavior that indicates whether the person is alert. Using the individual profile, alertness was scored every 15 minutes during one arbitrarily chosen day (from 9 a.m. until 5 p.m.) on the following scale: 1 = *active, focused on the environment*; 2 = *inactive, withdrawn*; 3 = *sleeping, drowsy*; and 4 = *agitated*. The Alertness Observation List has been found to be a reliable instrument in people with PIMD (Munde et al., 2011). The proportion of the day that spent "active, focused on the environment" (Score 1) was used to determine alertness. Measurements were conducted by test assistants, who were unaware of which participants were in which group.

Statistical Analysis

First, the data on alertness were checked for outliers using the Median Absolute Deviation (Wilcox & Keselman, 2003). In addition, we explored the pattern of missing data. Using Pearson chi-square tests, it was checked whether the missing data on alertness per measurement point could be explained by the exploratory categorical variables "group" (intervention or control condition), "visual impairment" or "motor impairment."

Next, we computed the mean score and standard deviation on alertness for the control and intervention groups at each measurement. We analyzed the change in alertness per group and individual by making individual plots and checked whether multilevel analysis supported the pattern found in the plots. Multilevel modeling was used to model the change of the alertness score, and we analyzed whether changes could be explained by the motor impairments and visual impairments of the participants. The correlation between the intercept and slope was computed to check whether variance was larger between measurements than among participants.

The multilevel analysis started with the empty model. Next, we created the fully multivariate model. Then we created three different models: one for the effect of group over time, one for the effect of visual impairment and group over time and one for the effect of motor impairment and group over time. Deviance tests were used for model comparison (Snijders & Bosker, 2011). Significance of the parameters in the model was determined as described in Snijders and Bosker (2011). Although some variables were not significant, they were retained in the analysis based on their theoretical relevance to the research question (Snijders & Bosker, 2011).

RESULTS

Outliers and Missing Data on Alertness

There were no outliers related to alertness. Missing data on alertness on the different measurement points could not be explained by the exploratory categorical variables "group,"

TABLE 2. Mean and Standard Deviation for Alertness in Percentages for the Intervention and Control Groups at Baseline (T0), Mid Measures (T1, T2, T3) and After the Intervention Period (T4)

Measurement	Number of Measurements	Group	
		Intervention *M* (*SD*)	Control *M* (*SD*)
Baseline (0)	29	61.64 (28.43)	64.47 (26.35)
1	20	69.80 (27.60)	62.80 (21.01)
2	27	61.88 (32.88)	62.09 (20.72)
3	27	63.50 (32.37)	59.62 (13.40)
4	26	66.00 (33.10)	71.14 (26.37)

"visual impairment," and "motor impairment," apart from a relation between the missing values at T3 and the level of impairments (more missing values in partial visual impairment; $\chi^2[1] = 8.826$, $p = .003$).

Alertness

Table 2 presents the means and standard deviations for the measurement points on alertness for the intervention and control group. Figures 1 and 2 present the distribution for each

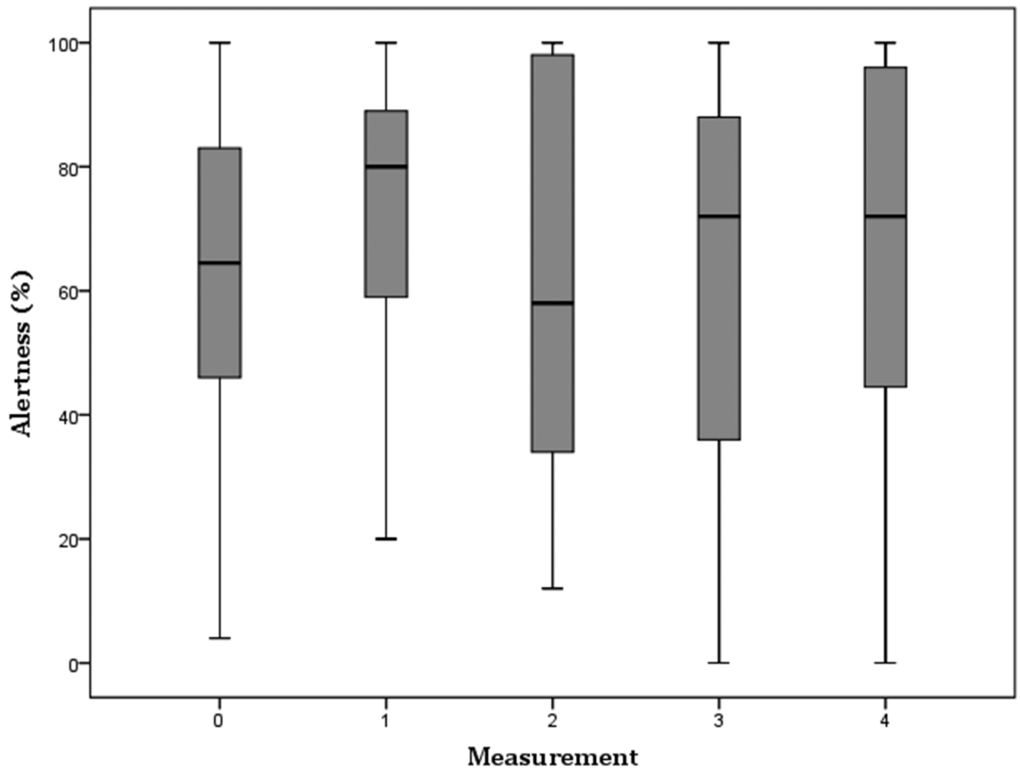

FIGURE 1. Distribution for each measurement of alertness in the intervention group.

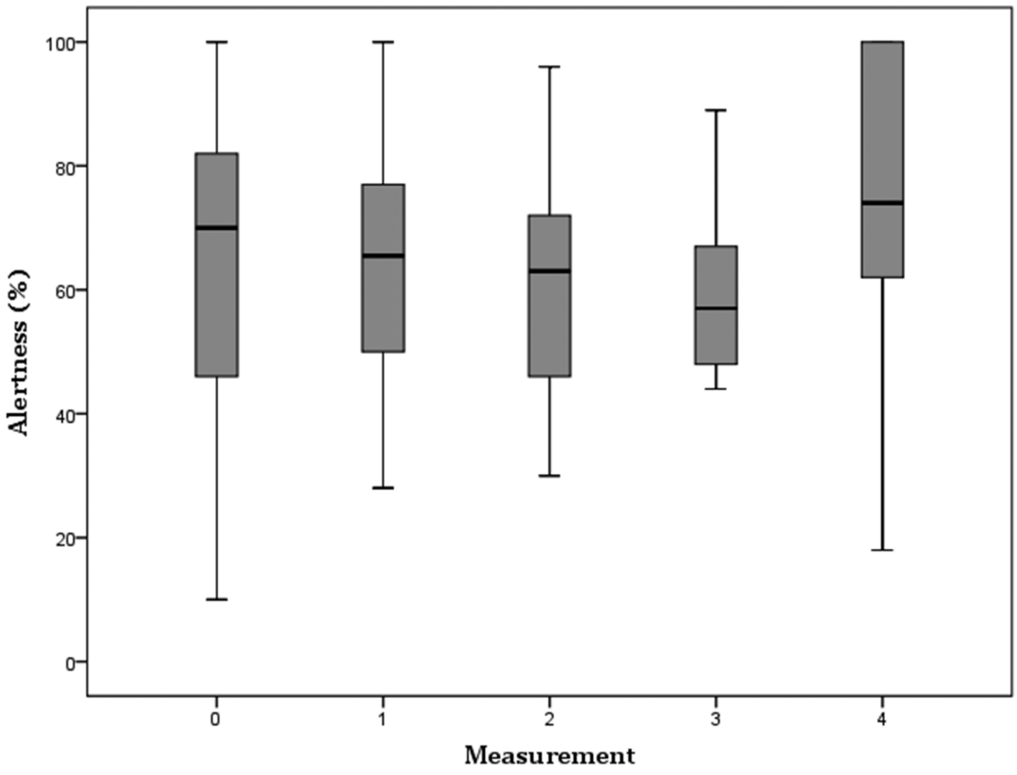

FIGURE 2. Distribution for each measurement of alertness in the control group.

measurement point of alertness in the intervention and control group. In the intervention group, there was an increase at T1, which later declined. In the control group, the mean score decreased at T1 and increased at T4.

Individual Changes in Alertness Over Different Measurement Points per Group

The change in alertness over different measurement points per individual can be found in Figures 3 and 4. The first point is the baseline measurement, after which the intervention started. The plots show a large variation in change in alertness between the participants. This variation is apparent in the intervention group as well as in the control group. Based on the plots, no clear increase can be seen in the intervention group compared to the control group. A ceiling effect can be seen in the plots for some participants (e.g., Participants 7 and 13).

Effect of the Intervention and Relationships With Visual and Motor Impairments

The plots in Figures 3 and 4 show a large variance between participants. The intraclass correlation coefficient (ICC) of the empty model shows that the variance between participants is far larger than between measurements differences (ICC = 0.66). Sixty-six percent of the total variance in alertness can be attributed to variance between participants.

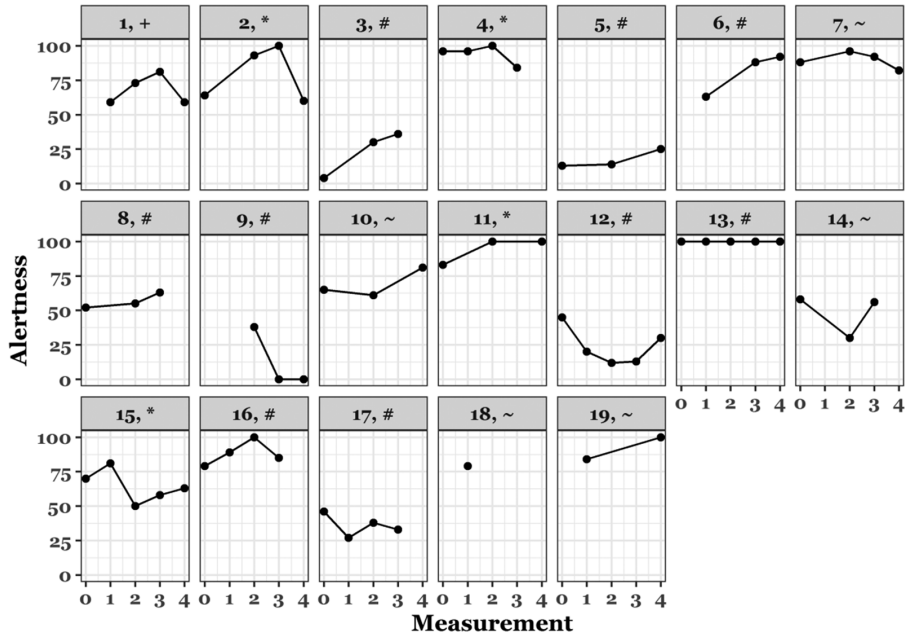

FIGURE 3. Changes in alertness per group and individual for the intervention group. * = blind, GMFCS IV; # = blind, GMFCS V; + = partial visual impairment, GMFCS IV; ~ = partial visual impairment, GMFCS V; GMFCS = Gross Motor Function Classification System.

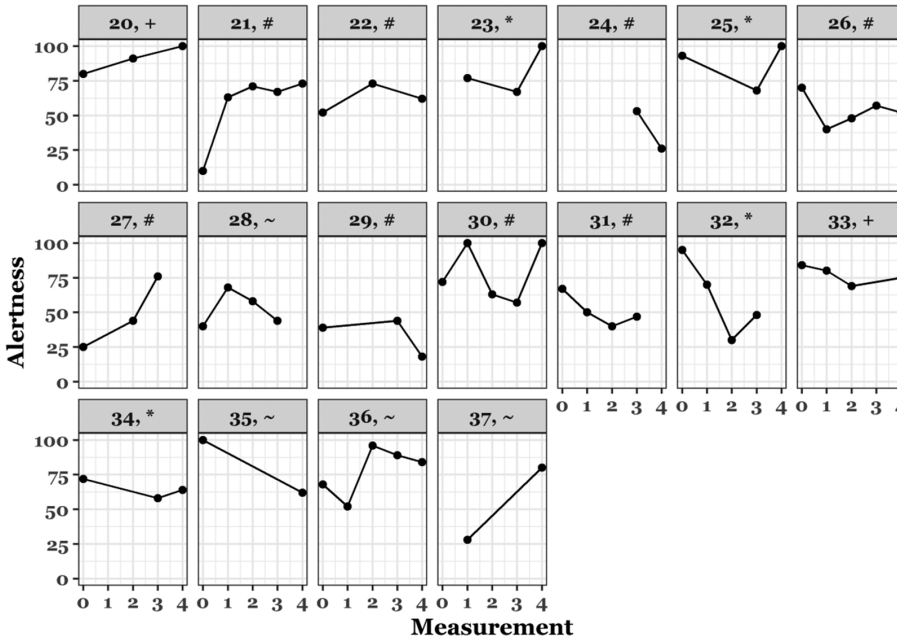

FIGURE 4. Changes in alertness per group and individual for the control group. * = blind, GMFCS IV; # = blind, GMFCS V; + = partial visual impairment, GMFCS IV; ~ = partial visual impairment, GMFCS V; GMFCS = Gross Motor Function Classification System.

The final model for the effect of group over time demonstrates that the alertness scores for the intervention group did not increase more than those for the control group (Group × T1: 4.43, $SE = 9.62$; Group × T2: 7.54, $SE = 9.62$; Group × T3: 3.19, $SE = 9.19$; Group × T4: −4.13, $SE = 8.63$). Including the effect of group over time did not result in a significant increase in model fit when compared to the fully multivariate model ($\chi^2 = 2.22$ (5), $p = 0.82$).

The final model for the effect of visual impairment shows that visual impairment had no overall significant effect on alertness (Coefficient = 13.63, $SE = 8.96$). It also had no significant effect on the effect of the intervention over time (Visual impairment × Group × T1: 0.44, $SE = 15.55$; Visual impairment × Group × T2: −4.27, $SE = 12.82$; Visual impairment × Group × T3: 7.36, $SE = 12.96$; Visual impairment × Group × T4: −1.34, $SE = 12.71$). Thus, the severity of the visual impairment did not influence the effect of the intervention over time. Including the effect of visual impairment over group over time did not result in a significant increase in model fit compared to the fully multivariate model ($\chi^2 = 5.19$ (6), $p = 0.52$).

The final model for the effect of the GMFCS score shows that the GMFCS score had an overall significant effect on alertness (Coefficient = 18.04, $SE = 7.89$). This indicates that participants with a GMFCS Level V score were, on average, 18.04% less alert than the participants with a GMFCS Level IV score. Nevertheless, the GMFCS variable did not influence the effect of the intervention on alertness over time (GMFCS score × Group × T1: 8.76, $SE = 12.11$; GMFCS score × Group × T2: 9.23, $SE = 11.84$; GMFCS score × Group × T3: 10.83, $SE = 12.01$; GMFCS score × Group × T4: −13.12, $SE = 11.80$). The model resulted in a significant increase in model fit when compared to the fully multivariate model, ($\chi^2 = 15.18$ (6), $p = 0.02$).

DISCUSSION AND CONCLUSION

This study focused on the effects of a power-assisted exercise intervention on alertness in people with PIMD. Moreover, it analyzed the relationship between the participants' visual and motor impairments and the intervention's effect on alertness. Results showed that the intervention did not significantly increase alertness for all the participants. However, there was a wide variation among participants. For some of them, the intervention did seem to have an effect over time.

By looking at motor and visual impairments, it was tried to explain the differences in the intervention's effect by looking at the differences in participants' motor and visual impairments, but no relationship between the severity of their impairments and the intervention's effect was found. However, GMFCS scores had a significant effect on the alertness score in general, which means that participants with more severe motor impairments were less alert in general.

These results are not in line with our expectations. Several other studies have found that implementing interventions based on motor activation increases alertness in people with profound intellectual and/or multiple disabilities. For instance, Jones et al. (2007) found that the use of trampolines by people with PIMD resulted in a higher level of alertness and less time spent unengaged. Moreover, Cuvo et al. (2001) found that outdoor activities increase the engagement of adults with a profound intellectual disability. Lancioni, O'Reilly, Campodonico, and Mantini (1998) found that people exhibited more engaged behavior for tasks involving motor activation than for tasks involving sedentariness.

These conflicting results could probably be explained by the characteristics of the interventions. For example, Jones et al. (2007) focused on the use of trampolines to stimulate alertness, and Cuvo et al. (2001) studied the effect of outdoor activities. The power-assisted exercise intervention supports the participant in performing exercises such as sit-ups, hip flexion, spreading and closing arms and legs, and moving arms and legs up and down. The use of a power-assisted exercise intervention may have stimulated motor activation less than the use of trampolines or outdoor activities because a person lies down on the machine while being supported in moving (Jacobson et al., 2012). The differences in results could be explained by the specific characteristics of the power-assisted exercise intervention compared to the characteristics of other motor interventions for people with PIMD (Bossink et al., 2017). Further studies should examine the effectiveness of the different characteristics of motor interventions for people with PIMD.

Another possible explanation for the results could be that alertness was not measured immediately after the time spent on the power-assisted exercise machines but on a different day. This study focused on the intervention's long-term general effect on alertness. Although we found no long-term effect, there could be a within-session effect (Lancioni, Cuvo, & O'Reilly, 2002). In future studies of increasing alertness, it would be interesting to see whether measuring alertness during the intervention would lead to different results because the intervention may only have a short-term effect. However, even if a within-session effect could be found, the long-term effects outside the intervention sessions appear to have a greater practical relevance (Lancioni et al., 2002).

The use of a multilevel modeling methodology has multiple benefits. It can integrate dependency in a nested structure and detect different patterns of alertness for different people (Snijders & Bosker, 2011). In this study, it was difficult to detect results that could be of practical relevance because all the coefficients were rather small or had a large standard error. Power was also low because of the small sample size. Therefore, we decided to analyze the visual and motor impairments in two different models to be able to look at trends. Multilevel modeling also makes it possible to look at the model fit (Snijders & Bosker, 2011).

Multilevel analysis showed that the variation between people is higher than the variation within people. This indicates that there is considerable variation among individuals, which corresponds to the characteristic of heterogeneity of the group of people with PIMD (Nakken & Vlaskamp, 2007). Therefore, the intervention may increase alertness for some people with PIMD but not for others. The variation among people could not be explained by the variables included in this study: motor impairments and visual impairments. Further studies could consider the characteristics of the intervention or different characteristics of the person with PIMD (e.g., pain or seizure disorder) to reduce the variation between people and to better understand for which people the intervention may be more effective.

This study emphasizes the importance of developing evidence-based interventions for people with PIMD. Moreover, the results underline the importance of looking at the effectiveness of interventions that are already being used in daily practice. Those interventions may not be as effective as expected, which could have negative consequences (e.g., high costs and time that could have been spent on more effective interventions). Thus, this study underlines the importance of evaluating, on an individual level, the intervention used. However, this is rarely done. The study by Vlaskamp and Nakken (2008) found that nearly a third of the therapeutic interventions that were in use were not clinically evaluated; therefore, it could not be determined whether an intervention is beneficial on an individual level.

This study involved a randomized controlled trial, which is often considered to be the gold standard in research. However, this may not apply to every circumstance (Grossman & Mackenzie, 2005). This study may be such an exception. Because the group of people with PIMD is heterogeneous, it is difficult to consider all the variables that may influence an intervention's effect.

Another option would be single case studies (Horner et al., 2005). Although often criticized for having a lack of objectivity and results that cannot be generalized, case studies can offer insights that may not be achieved with other techniques. They are often used in the exploratory stage of research projects (Rowley, 2002). Because they focus on the individual, they allow a detailed analysis of the different participants (Horner et al., 2005). Case studies can therefore be useful in improving support for people with PIMD.

Although this study did not find that the power-assisted exercise intervention had any significant effects on alertness, this does not necessarily mean that it cannot be beneficial to anyone with PIMD. Moreover, the power-assisted exercise intervention could affect other outcome measures that were not considered in this study. Therefore, it is important to determine on an individual level (e.g., in an individual care plan) whether the intervention is beneficial, what specific outcomes can be expected, and how these effects can be noticed. For example, if the aim of an intervention is to increase alertness, the individual care plan should clearly state why it is expected that the intervention would have this effect on the individual and how this effect can be measured.

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