Measuring physical fitness in persons with severe or profound intellectual and multiple disabilities
Waninge, Aly

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Chapter 8
Heart Rate Pattern as an Indicator of Physical activity in persons with Profound Intellectual, and Multiple Disabilities.

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Abstract

Background As physical fitness is related to physical activity, it is important to gain insight into the physical activity levels of persons with Profound Intellectual and Multiple Disabilities (PIMD). Heart rate monitoring may be used as an indicator of activity levels, yet a correct method for dating heart rate patterns of subjects with PIMD has so far not been researched.

Objective The purpose of this study was twofold. First, this study examines the activity levels of persons with Profound Intellectual and Multiple Disabilities (PIMD) based on their heart rate patterns, contrasted against American College of Sports Medicine (ACSM) guidelines of healthy physical activity. Second, this study describes the relation between various covariates and heart rate patterns and proposes adherent classification.

Method Using a heart rate monitor, heart rate patterns of 24 subjects with PIMD were measured during 6 days. Heart rate intensity was calculated using heart rate reserves. Physical activity levels were also measured with questionnaires. Data were analyzed using multilevel analysis.

Results The results show that the mean heart rate zone of the participants over six days is 3.196, indicating 32% of the heart rate reserve. The intensity ranged over a heart rate reserve from 1 to 62%. Wide ranges in heart rate between participants and within one day have been shown. However, between days we found small ranges in heart rate. Heart rate monitoring is a reliable measurement for measuring physical activity. Participants could be classified in 4 classes according to heart rate. Time of day, physical activity and age have significant influence on heart rate.

Conclusions In conclusion, persons with PIMD are not sufficiently physically active based on the guidelines of ACSM. Heart rate monitoring seems to be a reliable indicator of physical activity, but exploration of the other influential factors, such as emotions and personal factors, is recommended.
Introduction

It is important to gain insight into the physical activity levels of persons with profound intellectual, visual, and severe motor disabilities (profound intellectual and multiple disabilities, PIMD). Persons with PIMD risk low levels of physical activity [1, 2] and the associated negative effects on health. Physical activity improves both mental health, physical health, physical fitness [3], and participation in daily life [4]. Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure [5]. However, for a substantial gain in physical fitness, the ACSM guidelines state that physical activity has to be performed 5 days a week for at least 30 minutes a day with an intensity of more than 55% of the heart rate reserve [6].

Persons with intellectual disabilities are often not sufficiently active to achieve benefits in health or improve fitness levels [2, 7, 8]. Additionally, physical fitness in persons with a visual disability is poorer than in persons without disabilities [9, 10, 11], and persons with both severe intellectual and visual disabilities have a high chance of experiencing a variety of limitations in daily functioning such as inactivity, insecure movement and little initiative [12]. However, research into the physical activity levels in persons with PIMD is limited and knowledge on the topic is scarce.

Due to severe multiple disabilities, physical activity levels of persons with PIMD are difficult to reliably quantify [13]. These persons often also suffer from sensory integration problems [14], and inadequacies in perception and motor-reproduction [15, 16]. Furthermore, co-morbidity, such as cerebral palsy, is more frequent in those with intellectual disabilities than in the general population [17]. As a result, persons with PIMD have generally very limited mobility, use a wheelchair [18], and have a Gross Motor Function Classification System level IV and V (GMFCS) [19]. Consequently, normal tests, such as the usage of walking, are not applicable for persons with PIMD [13]. Moreover, the presumed low levels of activity in persons with such profound disabilities are often not accurately presented by relatively insensitive measurement devices, like activity monitors [13]. In addition, there are no existing algorithms for predicting activity energy expenditure of persons with PIMD.

Physical activity studies often use a combination of assessment methods [20, 21] including heart rate monitoring, which is an objective method [22], combined with direct observation, which is a criterion method [22]. Heart rate monitoring may be used as an indicator of activity levels when assuming a relationship between activity intensity and heart rate [23, 24]. Heart rate monitoring appears to be sufficiently valid to use in creating broad physical activity categories (e.g. highly active, somewhat active, sedentary) [25]. As stated before, only heart rates of more than 55% of the heart rate reserve may gain profit for physical fitness, if obtained during 5 days in a week [6]. Thus, heart rate monitoring may tell us if we can actually increase the persons’ fitness.

However, the correct method of dating heart rate patterns of individuals with PIMD as well as the correlation between heart rate monitoring and activity levels for this specific group have so far not been subject to research. What is more, also the influence of covariates such as gender and age on the heart rate patterns of individuals with PIMD is unknown. For persons with and without disabilities, physical activity is gender related [18]. Heart rate is related to age [26], gender and activity [27]. As persons with PIMD often suffer from co-morbidity such as motor disability, spasticity and sensory disabilities, it seems useful to examine the influence of these covariates on heart rate height as well.
Furthermore, practical experience learns that as a consequence of co-morbidity, the skills of persons with PIMD vary greatly. Moreover, Vlaskamp et al. [28] found days in the PIMD activity centres to be highly structured, with each activity taking place at the same time and day. These findings suggest the possibility of a relation between heart rate patterns and subgroups plus time of day.

The purpose of this study, therefore, was fourfold: firstly, to determine the activity levels of persons with PIMD based on heart rate patterns when compared to ACSM guidelines of healthy physical activity; secondly, to analyze heart rate patterns according to group differences, days, time of day and to establish adherent classification in heart rate height and patterns; thirdly, to determine the relation between heart rate patterns and observed level of activity in persons with PIMD; and, fourthly, to examine the influence of covariates such as gender, age, and common co-morbidity (motor disabilities, spasticity and sensory disabilities) on heart rate patterns.

Materials and methods
Participants
The target population of our study comprises of persons with PIMD, characterized by severe or profound intellectual disability indicated by an intelligence quotient under 40 points. The participants have a developmental level lower than six years (International Association for the Scientific Study of Intellectual Disabilities, IASSID) [29], and are thus severely limited in self-care, continence, communication, and mobility [30].

All participants were recruited from a Dutch residential care facility, which houses 200 persons with severe or profound intellectual and visual disabilities. The inclusion criteria were: presence of severe or profound intellectual disability, visual disability, and motor disability with GMFCS level IV or V [19]. For 48 persons, representatives were requested to give a written permission for participation in this study, of which 30 were obtained. Both a physician specialised in mental disabilities and a behaviour scholar screened the participants for our exclusion criteria, being severe psychological problems or somatic diseases defined as chronic diseases and/or diseases that do not resolve in the short term.

Four persons were excluded from the study because they showed one of these problems or diseases. The exclusion criteria at the time of the measurements were: general illness or fever; taking antibiotics; worsening of asthma, epilepsy (recent insult or epileptic fits), fresh wound(s)/bruise(s), or other factors causing pain during movement; or stress due to the subject’s behavior just before the measurement dates. Two persons were excluded because they presented one of these signals. Figure 1 presents the sampling scheme of persons included in the study.
18 persons lacked permission from representatives

4 persons excluded for medical/behavioral reasons

2 persons excluded at the time of the measurements

Figure 1. Sampling scheme of subjects included in the study

All participants were classified according to the GMFCS [19]. Furthermore, visual and auditory impairments of the participants were classified according to WHO guidelines [4]: a distinction was made between being severely partially sighted and being partially sighted as well as between severe hearing loss, slight hearing loss and normal hearing. Spasticity was classified as unilateral, bilateral or unknown [31]. Orthopedic defects were used as an indicator of locomotor disabilities and classified as present or not present.

Ethical statement
This study was performed in agreement with the guidelines of the Helsinki Declaration as revised in 1975. Permission to carry out the study was obtained from the institutional ethics committee. Informed consent was obtained from representatives of the participants, because the participants were not able to give consent. The measurements were performed in accordance with the behavioural code section entitled ‘Resistance among people with an intellectual disability in the framework of the Act Governing Medical-Scientific Research Involving Humans’ [32]. Consistent distress or unhappiness was interpreted as a sign of lack of assent and further participation in the study was reconsidered.

Study design
Heart rate patterns were measured in each participant 8 hours a day for a period of six days. Every 15 minutes measurements were conducted, resulting in a total amount of measurements a day of 32 (8 hours, 4 times 15 minutes). 5 Out of the 6 test days were weekly, the remaining day fell in the weekend. Parallel with heart rate measurements, physical activities were registered using direct observation, noted down in score lists.

Measures
Heart rate patterns were measured with a heart rate monitor (Polar RS 800, Kempele, Finland) whose heartbeat data were transferred later to a computer. Heart rate was monitored in every participant during 6 days during 8 hours a day.
Data regarding physical activity were registered with the use of a questionnaire, which was filled out by both personal caregivers at the living group as support staff of the activity centre. Physical activity was coded as ‘Targeted physical activity Yes’ or ‘Targeted physical activity No’. Moving with the wheelchair inside or outside, transfer, active sitting without support, gymnastics with a gymnastic instructor, physical therapy, playing with a ball, and ‘dancing’ on music were all examples of ‘Targeted physical activity Yes’. Listening to music, watching television or lying down on a bed were all examples of ‘Targeted physical activity No’.

**Data analysis**

**Heart rate zones**

Peak heart rate, rest heart rate and heart rate reserves differ for each person, which makes them difficult to compare. By calculating heart rate zones according to the equation of Karvonen [33], it is possible to compare the zones of the participants with each other.

Heart rate zones are calculated as follows. First, each participant’s peak heart rate was estimated using the formula of Fernhall [34] for participants with intellectual disabilities: 210 - 0.56 (age) - 15.5. Due to the motor disabilities of the participants, no other non-invasive measure could be performed. Secondly, the participants resting heart rate was determined by taking the median of fifteen morning heart rate measurements. Thirdly, using the participants resting heart rate, the heart rate reserve was calculated by subtracting resting heart rate of estimated peak heart rate. Finally, the heart rate reserve was divided in 10 zones, each zone consisting of 10% of the heart rate reserve. The heart rate of a participant during each 15 minutes was classified in these zones. For instance: resting heart rate of 50 beats per minute (bpm), maximum heart rate of 180 bpm; heart rate reserve is 130 bpm; each heart rate zone exists of 13 heart rates, the first zone is from 50 to 63; the second from 63 to 76; and so on (Table 1).

Table 1. Example of the heart rate zones for healthy persons

<table>
<thead>
<tr>
<th>Heart Rate</th>
<th>Zone</th>
<th>Activity</th>
<th>Percentage of heart rate reserve (HRV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50-63</td>
<td>Rest</td>
<td>1-10</td>
</tr>
<tr>
<td>2</td>
<td>63-77</td>
<td></td>
<td>10-20</td>
</tr>
<tr>
<td>3</td>
<td>77-90</td>
<td>Quiet moving</td>
<td>20-30</td>
</tr>
<tr>
<td>4</td>
<td>90-103</td>
<td></td>
<td>30-40</td>
</tr>
<tr>
<td>5</td>
<td>103-116</td>
<td>Moderately intensive activity</td>
<td>40-50</td>
</tr>
<tr>
<td>6</td>
<td>116-129</td>
<td>ACSM guideline of healthy physical activity</td>
<td>50-60</td>
</tr>
<tr>
<td>7</td>
<td>129-142</td>
<td>Intensive activity</td>
<td>60-70</td>
</tr>
<tr>
<td>8</td>
<td>142-155</td>
<td></td>
<td>70-80</td>
</tr>
<tr>
<td>9</td>
<td>155-168</td>
<td>Very intensive activity</td>
<td>80-90</td>
</tr>
<tr>
<td>10</td>
<td>168-180</td>
<td></td>
<td>90-100</td>
</tr>
</tbody>
</table>

**Patterns and classes in heart rate**

Heart rate of the 24 participants was measured eight hours a day during six days, with measurements being conducted every 15 minutes. In order to determine the activity levels of persons with PIMD compared with ACSM guidelines of healthy physical activity, an overview of the heart rate zones is presented, along with a day to day outline of the mean prevalence of heart rate zones of the participants.
Furthermore, the mean and the ranges of heart rate zones of the participants are calculated. To gain insight into the heart rate patterns of persons with PIMD, three decomposing variance components are involved, using linear mixed model: 1) between persons, 2) within persons between days, and 3) within days. The mean heart rate and variance proportion component (VPC) were calculated between persons, within persons and between days. The VPC as an indicator of variance in heart rate zone, is calculated by dividing variance by the total variance. Using the variance proportion component the generalizability coefficient for the relative differences [35] was calculated. A generalizability coefficient of 0.80 or more indicates a sufficient reliability. Furthermore, in order to identify distinct groups of heart rate patterns and to examine these classes in heart rate, we used a latent class analysis [36, 37]. As the dependent variable was a count variable, a Poisson distribution was used for this analysis.

Relations between heart rate patterns and level of activity
To determine how heart rate relates to the level of physical activity, we estimated equations of physical activity as a dependent variable of heart rate. Furthermore, we examined the influence of ‘time of the day’ on this relation.

Influence of covariates
The influence of the covariates gender, age, time of day, daily activities, motor disabilities, spasticity, and sensory disabilities were evaluated in the mixed model.

Results
The data were analysed using SPSS 16.0 and multilevel analysis with the computerprogram Mlwin [38].

In total, 24 persons with PIMD participated in this study. Six women participated with a mean age (SD) of 30 years (17), the mean age (SD) of the men was 36 years (15). Table 2 shows the characteristics of the participants.
Table 2. Characteristics of the participants

<table>
<thead>
<tr>
<th>Characteristics of the participants</th>
<th>Gender</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td><strong>Intellectual disability</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe</td>
<td></td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Profound</td>
<td></td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td><strong>Visual impairments</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blind/Severe</td>
<td></td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>Partially</td>
<td></td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td><strong>Orthopedic defects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td><strong>Spasticity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>18</td>
<td>6</td>
</tr>
<tr>
<td><strong>GMFCS level</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>V</td>
<td></td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>18</td>
<td>6</td>
</tr>
</tbody>
</table>

Patterns and classes in heart rate
Table 3 shows a day to day outline of the mean prevalence of heart rate zones in persons with PIMD, indicating that the participants reach no heart rates more than 55% of their heart rate reserves for a consecutive 30 minutes.
The mean heart rate zone over the six test days is shown under the heading 'intercept' model 0 in \( \text{table 4} \), and is 3.196, indicating 32% of the heart rate reserve. The results range from 1 to 62% of the heart rate reserve (see \( \text{table 3} \)).

The model in \( \text{table 4} \) shows the variance between participants (0.911), between days (0.161) and within one day (0.429). As the total variance is the sum of these variances (1.501), the VPC between the participants is 60.7%, between days 10.7%, and between different times of the day 28.6%. These VPC's indicate that the variation between the test days is relatively low, suggesting that future research can do with one test day instead of six. The generalizability coefficient for the relative differences, calculated with the variance proportion components, is 0.85, indicating that heart rate monitoring is a reliable measurement.
Table 4. Variability of heart rate and linear mixed models.

<table>
<thead>
<tr>
<th>Variable</th>
<th>B-value</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(person level)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intercept</strong></td>
<td>4.217</td>
<td>0.655</td>
</tr>
<tr>
<td><strong>Time of day</strong></td>
<td>-0.007</td>
<td>0.001</td>
</tr>
<tr>
<td><strong>Activity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Targeted activity vs no targeted (ref)</td>
<td>0.021</td>
<td>0.021</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>-0.023</td>
<td>0.012</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>-0.041</td>
<td>0.409</td>
</tr>
<tr>
<td>Male vs female (ref)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Orthopaedic defects</strong></td>
<td>-0.257</td>
<td>0.577</td>
</tr>
<tr>
<td>No orth defects vs orth defects (ref)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Spasticity</strong></td>
<td>0.499</td>
<td>0.867</td>
</tr>
<tr>
<td>Bilateral vs unilateral parese (ref)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Visual impair</strong></td>
<td>0.185</td>
<td>0.39</td>
</tr>
<tr>
<td>Severe partially vs partially impaired vision (ref)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Auditive impairment</strong></td>
<td>-0.606</td>
<td>0.593</td>
</tr>
<tr>
<td>Severe hearing loss vs slight hearing loss vs normal hearing</td>
<td>-0.735</td>
<td>0.462</td>
</tr>
<tr>
<td><strong>Random</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participant</td>
<td>0.911</td>
<td></td>
</tr>
<tr>
<td>Days</td>
<td>0.161</td>
<td></td>
</tr>
<tr>
<td>Time of day</td>
<td>0.429</td>
<td></td>
</tr>
<tr>
<td>Total var</td>
<td>1.501</td>
<td></td>
</tr>
<tr>
<td>2Loglikelihood</td>
<td>10302</td>
<td></td>
</tr>
</tbody>
</table>

B-value, the regression-coefficient; SE, standard error; vs, versus; ref, reference value.

With the variable age, time of the day and the observations measured at six different days, we found a four class solution that gives a clear clinical interpretation [36, 37]. The four class classes were: high heart rate zone (class 1), middle stable heart rate zone (class 2), low heart rate zone (class 3) and variation in the middle heart rate zone (class 4).
Relation between heart rate patterns and level of activity
The relation between time of the day and heart rate is significant (regression-coefficient: 0.007 with SE 0.001; p < 0.01) (see model in table 4). The relation between physical activity and heart rate shows a regression-coefficient of 0.041 with SE of 0.021 (p = 0.02), which is a significant relation too. However, if ‘time of the day’ is brought into the equation, there is no significant influence of ‘physical activity’ on heart rate anymore (regression-coefficient 0.022 with SE 0.021; p = 0.147), only ‘time of the day’ remains of influence (-0.007 with SE 0.001; p < 0.01).

Therefore, we examined the relation between ‘time of day’ and ‘daily activity’, based on the questionnaires filled out by the caregivers. Figure 2 shows the percentage active persons as a function of the time of the day. Figure 2 illustrates that most participants are active between 9.00 and 12.00 o'clock. During the day the percentage active persons decreases. Between 12.00 and 13.00 o'clock most participants seem to rest. Between 13.30 and 16.00 o'clock most participants become active again, but afterwards activity decreases once more.

![Distribution of the six days](image)

**Figure 2.** Relation between ‘time of the day’ and ‘activity’: the percentage active persons as a function of the time of the day, based on the questionnaires.

Influence of covariates
Table 4 shows the influence of covariates. Age has a significant influence. Higher ages yielded lower heart rate zones. Also time on the day has a statistical significant influence: later on the day yielded lower heart rate zones. Gender, spasticity, intellectual level and hearing had no significant influence.
Discussion

This study examined firstly the activity levels of participants with PIMD based on their heart rate patterns when contrasted against ACSM guidelines of healthy physical activity [6]. Secondly, this study researched the relation between various covariates and heart rate patterns and proposed adherent classification.

Our study shows that the participants reach no heart rates more than 55% of their heart rate reserves for a consecutive 30 minutes, which indicates that they are not sufficient physical active based on the guidelines of ACSM [6]. Wide ranges in heart rate between participants have been shown. In addition, within one day wide ranges in heart rate are present. However, between days we found small ranges in heart rate. The generalizability coefficient (>0.80) indicates that heart rate monitoring is a reliable method for measuring physical activity. Participants could be classified in 4 groups according to heart rate. Time of day, physical activity and age have a significant influence on heart rate. However, the relation between time of day and physical activity is very strong and when corrected for ‘time of day’, ‘physical activity’ ceases to have a significant influence on heart rate. As a consequence, heart rate seems to be an indicator of physical activity of individuals with PIMD, but further exploration of other possible factors is still needed.

This study is an important first step in exploring heart rate patterns of the intellectually disabled for a full day. Due to their locomotor disabilities, examination of the peak heart rate with a maximal heart rate test is not possible. Therefore, we had to use the formula of Fernhall [34], which is an estimate and may therefore be less reliable. Based on our results we recommend further exploration of heart rate patterns in this target group.

The mean heart rate zone of all participants over six days is 3.2. This indicates they use relatively little, only 20 to 30 percent, of their heart rate reserves. Although the range of percentages of heart rate reserves was found to be between 1 and 62 %, levels higher than 55 % for at least a consecutive 30 minutes were not reached. It appeared to be difficult to activate these persons into physical activity. This may be explained by the multiple disabilities of our target group. Persons with GMFCS levels IV and V have little skills to move actively and are hindered by visual impairment and lack of comprehension. The individual combinations of these limitations may explain the four classes we distinguished in heart rate patterns. Future research should be directed towards the examination of these classes and the possible influence of interventions on these classes.

Caregivers in the living situation as well as caregivers in the activity centre filled out the questionnaires for registration of physical activity used in our analysis. Analysis of this registration brings forward a figure similar to that of the heart rate patterns. The mean number of offered motor activities was 0.8 per day (range: 0-3.3; SD: 1.1) and the mean duration of motor activation was 26 minutes per day (range: 0-163; SD: 35) [39]. The present study yielded a negative correlation between heart rate and age. Van der Putten & Vlaskamp [39] found a negative correlation between daily activity and age. As heart rate height and physical activity are supposed to be related [3], our results are in line with the results of Van der Putten & Vlaskamp [39].

Furthermore, the majority of observed motor activation took place during ‘daily care situations’, whereas only 18% of these situations existed of targeted motor activation. 61 % Of the activities were passive in nature [40]. The conclusions of these authors were that motor activation is a minor part of the support of persons with PIMD. Moreover, analysing the heart rate...
patterns in this study we can conclude that they do not meet the ACSM recommendations for health related physical fitness [6].

The significant relation between time of the day and heart rate may partly be declared by the circadian rhythms. The circadian system, driven by the suprachiasmatic nucleus, regulates properties of cardiovascular function, like blood pressure and heart rate [41, 42].

Furthermore, the relation between time of day and heart rate may be an illustration of the highly structured days in the activity centres of our participants. This is in line with the findings of Vlaskamp et al [28]: in 6 care facilities in the Netherlands it seemed to be common practice to have one activity in the morning, mostly between 10 and 11 AM, and one in the afternoon, roughly between 2 and 3 PM. This degree of structure already made us expect a low difference in heart rate patterns between days. Yet, is such structure desirable? Would an alternating day rhythm result in more activation of persons with PIMD? On the other hand, the advantage of the low difference in test results between days is that for future research one day of testing suffices, which is efficient.

We found no significant relation between heart rate and gender, intellectual level or co-morbidity as motor disabilities, spasticity and sensory disabilities when looking at 8-hours heart rate patterns. In order to test for any possible significant relation future research could set up subcategories, controlling for groups with a specific co-morbidity using groups without that specific co-morbidity.

Heart rate height as a predictor of antisocial behavior in adolescents was examined in a study of Sijtsema et al [43]. Their findings showed that heart rate measures obtained with a strict acquisition and analysis protocol were associated with antisocial behavior in boys but not in girls. In other studies it was found that in childhood and adolescence, low heart rate is one of the strongest correlates of antisocial behavior [44]. Furthermore, according to the stimulation-seeking theory, some adolescents are constantly under aroused, which is presumably marked by a low heart rate and a subjective unpleasant state [45]. Given the low heart rate zones in our study population, aforementioned research suggests examining the subjective well-being of these participants may be of crucial importance.

Physiological outcome measures as an indicator of subjective well-being were already explored by Vos et al [46] in persons with PIMD. People with PIMD showed more parasympathic activation when experiencing negative emotions. Most likely this is due to attention regulating processes. They also show a higher heart rate when the emotion intensifies. Nevertheless, the authors caused the readers to be careful when interpreting their findings since there were several limitations to their research. Taking all these findings into account, further research on the relation between heart rate of persons with PIMD and psychosocial variables such as emotions is recommended.

In conclusion, persons with PIMD do not attain sufficient activity levels according to ACSM guidelines. Heart rate monitoring seems to be a reliable indicator of physical activity. Time of day and age have considerable influence on heart rate patterns. However, the observed classes in heart rate patterns suggest other, probably more personal and psychosocial factors to have a significant influence on heart rate patterns as well. Further research into these factors is recommended.
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