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ARTICLE *in* JOURNAL OF HEALTH PSYCHOLOGY · FEBRUARY 2016

Impact Factor: 1.22 · DOI: 10.1177/1359105316628758

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Article

JHP

Journal of Health Psychology
1–5

DOI: 10.1177/1359105316628758
hpq.sagepub.com
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Does reactivity to accelerometers occur in a single trial? Brief report in a sample of young adults

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Abstract
This study aimed to test acute reactivity during a physical activity in an outdoor setting and to verify the relative perceived performance. In all, 38 volunteers wore accelerometers or not and completed two 20-minute sessions of self-selected pace physical activity. Covered distance, exertional responses, and perceived efficacy were recorded at the end of every session. Relevant finding of this study has been that reactivity to accelerometers also occurs in acute condition. Consequently, this condition leads to a better performance and a greater perceived exertion. Moreover, this situation seems to occur in a state of awareness.

Keywords
accelerometers, affective responses, perceived exertion, physical activity, reactivity

Introduction

Physical activity (PA) is a major public health concern. Indeed, correct PA levels reduce risks for several diseases and health conditions and improve physical and mental health. The use of motion sensors (such as pedometers and accelerometers) to measure PA is becoming a standard methodology. They provide an accurate and reliable objective measure of the volume and the intensity of PA (Atkin et al., 2012). In addition to their use as an assessment tool, motion sensors seem to strengthen the results of PA promotion interventions aimed to prevent health-related diseases (Allet et al., 2010; Compernolle et al., 2015; Heat et al., 2012).

Despite the advantages of these devices, many studies identified reactivity as a possible bias in this measures (Clemes and Deans, 2012; Clemes and Parker, 2009). Reactivity is a phenomenon that occurs when individuals alter their performance due to the awareness that they are being monitored by a device (Intille et al., 2012), it is also typical of physically active participants and could occur when researchers pay attention to people involved in a study or due to the enthusiasm of wearing measurement device (Heppner et al., 2008).

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Reactivity has been investigated measuring day-by-day variability during periods of at least 1 week, with the same sensor, worn as sealed or unsealed (Scott et al., 2014) or by giving misleading information about tool measurement (Clemes and Deans, 2012).

The rating of perceived exertion (PE), defined as the perception of effort or fatigue that is experienced during exercise, has been causally linked to changes in running speed and physiological variables. However, psychological factors also appear to contribute to rated perceived exertion (RPE), especially changes in affect and cognitive focus of the athlete alters RPE (Baden et al., 2005). Introducing a new condition during an exercise session changes PE of participant while exercising.

At present, no other study has investigated whether reactivity occurs in a precise context with similar (environmental and motivational) conditions. In case that reactivity took similar place in a single trial measurement, this would represent a potential new bias of accelerometry. Additionally, it is not clear whether participants wearing an accelerometer during a single trial can perceive to alter their performance, and whether wearing an accelerometer is sufficient to influence PE. Therefore, the aim of this study was to test reactivity in response to wearing or not an accelerometer in acute condition during a PA outdoor setting (move around a mixed urban and natural route) and verify whether there is perceived performance (PP) alteration.

Method

Participants

A sample of 45 university students, blinded to the study aim was enrolled. Only 38 (20 males and 18 females), mean age of 22.01 ± 2.56 years, completed all trials. Criteria for inclusion of participants were good health, normal weight (body mass index $= 19.2 \pm 2.5\,kg\,m^{-2}$), not taking any medications known to affect cardiovascular, respiratory, muscular, metabolic or cognitive functions, and nonsmoking. Participants provided informed consent form and certified to have undergone a physical examination within the past year that revealed no conditions for which vigorous exercise would be contraindicated. This study design was approved by the University of Pavia Internal Board.

Measures

Sealed Fitbit One Accelerometers (Fitbit Inc., San Francisco, CA, USA) were used. Recorded data (counts per minute (cpm)) were not processed for this study's purposes. Covered distance was measured in meters, counting laps and summing parts of lap length. PP was estimated using a 0–10 visual analogue scale (VAS) answering to the question: "How much have you thought to be efficient during the trial?"

PE was estimated using RPE-Borg scale (Borg, 1982), a 15-point item measure extending from 6 to 20, with verbal anchors ranging from "no exertion at all" (6) to "maximal exertion" (20). PE was defined as the subjective intensity of effort and fatigue felt during exercise (Noble and Robertson, 1996).

Procedure

A 300-m long mixed urban and natural path has been created placing cones every 10 m to control the distance covered by the participants without giving them any feedback. On this track, students completed a familiarization trial and two 20-minute sessions moving at self-selected pace. We tested two conditions on every participant. In the accelerometer (A) conditions, participants were equipped with a sealed accelerometer while in the no accelerometer (NA) condition they were not. To avoid confounding between the conditions and the order effect, order of presentation of conditions was randomized across groups. In a randomized order, participants were equipped with a sealed accelerometer (A) or not (NA) and a crossover design was used to avoid confounding between the conditions and the order effect. Research team was allocated along the path and after 20 minutes from the start, the position of each participant on the track was recorded to later

Table 1. Differences between measured outcomes wearing or not accelerometers.

38 subjects (20M; 18F)	No accelerometer	Accelerometer	p	Effect size	Mean difference (Δ)
Covered distance (m)	2144.7 ± 653.2	2302.9 ± 652.5	<0.001	0.246	158.2 ± 407.3 (6.9%)[a,b]
Perceived exertion (Borg)	10.47 ± 2.4	11.32 ± 2.31	0.011	0.368	0.8 ± 2.1 (7.4%)[c]
Perceived performance (VAS)	4.16 ± 2.11	4.97 ± 2.07	<0.001	0.391	0.8 ± 2.3 (16.4%)

[a]Δ Covered distance versus Δ perceived exertion ($r = 0.789$; $p < 0.001$).
[b]Δ Covered distance versus Δ perceived performance ($r = 0.592$; $p < 0.001$).
[c]Δ Perceived exertion versus Δ perceived performance ($r = 0.633$; $p < 0.001$).

calculate covered distance. Participants were instructed to continuously move within the path for 20 minutes at self-selected pace and measure of covered distance was hidden in order to avoid feedback influence. The PE (Borg Scale) and PP (VAS) were recorded for each participant individually at the end of every session. To blind the study aim, researchers reported to participants that they were validating accelerometers in a mixed outdoor path and studying perception of pleasure and exertion.

Data analyses

Data are reported as mean ± standard deviation (SD), mean difference (Δ) ± SD, and percentage difference between A and NA. Paired-sample t test was used to determine whether there was a statistically significant ($p < 0.05$) mean difference for distance, PE and PP between A and NA. The effect size was expressed as Cohen's d using the mean and SD of the paired difference from the t test. Additionally, Pearson correlation r coefficients were calculated to examine the relationship of Δ covered distance with ΔPE and ΔPP and the relationship of ΔPE with ΔPP.

Results

Sample

Results listed in Table 1 show that participants covered more distance when endorsing an accelerometer compared to the NA condition, with a statistically significant increase of 158.16 m (95% confidence interval (CI), 24.29–292.03), $t(37) = 2.394$, $p < 0.05$. In A condition, participants had a higher PP than during NA condition, with a statistically significant increase of 0.82 m (95% CI, 0.07–1.56), $t(37) = 2.209$, $p < 0.05$. Participants had also a greater PE when endorsing an accelerometer compared to NA condition, with a statistically significant increase of 0.84 m (95% CI, 0.15–1.53), $t(37) = 2.394$, $p < 0.05$. Pearson r coefficient showed positive correlation between Δ of all pairs of the measured outcomes ($p < 0.001$). Correlation was strong between Δ covered distance and ΔPE, and moderate between Δ covered distance and ΔPP and between ΔPE and ΔPP.

Discussion

While accelerometers are commonly used in PA promotion intervention and PA research, many studies identified reactivity as a possible bias in this measures. However, no study explained if reactivity occurs in the same context with the same conditions. The main aim of this study was to investigate the effects of wearing or not an accelerometer in acute condition during PA outdoor setting. For this purpose, it was specifically tested a sort of "absolute" reactivity using a familiarization session, the same context condition and comparison measure. Additionally, we investigated the PP to verify a possible wrong perception during the trials.

Our study documents an effect of wearing accelerometers during an acute condition with an increased covered distance (7% extent). These results support earlier findings of pedometers reactivity in adults (Clemes and Parker, 2009; Motl et al., 2012). Moreover, since participants did not have to complete a goal but only to freely move around the path and they did not have a feedback from device or covered distance, reactivity occurred mainly thanks to participants' awareness of wearing an accelerometer as suggested by other studies (Heppner et al., 2008; Intille et al., 2012). The novelty of our results suggests that reactivity to accelerometer occurs in a 20-minute acute trial, a duration which could fit with the PA guidelines recommendations for a sedentary participant (World Health Organization (WHO), 2010). In fact, World Health Organization stated that sedentary people had benefit for health starting from 10 minute bout of PA, thus we demonstrated that a 20-minute bout of exercise could be enhanced by accelerometer use. This response can definitely improve health gain increasing intensity and distance of a short training session.

Furthermore, wearing accelerometers during an acute condition caused an increase in PP (19% extent) and PE (8% extent) with a positive correlation of the two scales with the covered distance. In other words, the PP and exertion increased with the covered distance implying that participants had a coherent perception of their performance and exertion. Therefore, wearing an accelerometer without live feedback does not seem to alter the PP during a walking on a mixed natural and urban path in young healthy adults.

A limitation of this study is the fact that participants were all young healthy volunteers, recruited from a specific student population. For this reason, it would be interesting to investigate whether similar responses to wearing an accelerometer in a single trial can also occur in children or in sedentary participants or in different environments.

In conclusion, reactivity has to be considered in field-base researches because it could affect results of a single test and return wrong data compared to usual exercise habits. On the other hand, if wearing devices enhances performance in acute condition, researchers could take advantage of it to improve single trial performance with participants who need to improve their exercise capacities such as obese, diabetic, and sedentary people. The findings from this study shed more light on the psychological processes that influence PA participation and assessment, a very important issue in public health policy. Further research, designed to explore more in depth the psychological mechanisms of reactivity, could be of great interest to expand these results.

Acknowledgements

M.V. and L.C. equally contributed to the work.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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