



What comes first, negative emotions, positive emotions, or moderate-to-vigorous physical activity?



Magdalena Kruk^{a,*}, Karolina Zarychta^a, Karolina Horodyska^a, Monika Boberska^a, Urte Scholz^b, Theda Radtke^b, Aleksandra Luszczynska^{a,c,**}

^a Wroclaw Faculty of Psychology, SWPS University of Social Sciences and Humanities, 30b Ostrowskiego Street, 53-238, Wroclaw, Poland

^b Department of Psychology, University of Zurich, Zurich, Binzmühlestrasse 14 / Box 14, CH-8050, Zürich, Switzerland

^c Trauma, Health & Hazards Centre, University of Colorado at Colorado Springs, 1861 Austin Bluffs Pkwy, Colorado Springs, CO, 80918, USA

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ABSTRACT

Background: Although there is no doubt that indicators of physical activity (PA), negative and positive emotions are associated, the order in which they operate is not well-established. In this study, we investigated indirect associations between a negative emotions indicator (emotional symptoms of depression; henceforth: depression), a positive emotions indicator (physical activity [PA] liking), and moderate-to-vigorous physical activity (MVPA), in order to identify which one of the three variables is likely to precede the others.

Methods: Data were collected twice, with a 7–8-month follow-up. 879 adults from the general population ($N = 879$ at Time 1, T1; $N = 603$ at Time 2, T2) filled in questionnaires measuring depression, PA liking and MVPA.

Results: Mediation analyses showed that a higher level of depression (T1) predicted a lower level of PA liking (T2) which in turn explained a lower MVPA level (T2). Additionally, a higher level of PA liking (T1) predicted a lower level of depression (T2), which in turn was associated with a higher MVPA level at T2. Analyses with MVPA operating as the independent variable or the mediator were not significant.

Conclusions: Results indicated that both negative and positive emotions precede rather than follow MVPA engagement.

1. Introduction

Physical activity (PA) is recommended for boosting mental health and well-being as well as for preventing negative emotions and related disorders, such as major depressive disorder (Teixeira, Vasconcelos-Raposo, Fernandes, & Brustad, 2013). Depression-related emotions and symptoms require particular attention, as according to the World Health Organization (WHO, 2017) by the year 2020, depressive disorders will be the second leading overall health concern for people of all ages and both genders. Research investigating PA in the general population should account for depressive symptoms, that constitute the key aspects of mental health and quality of life (Deslandes et al., 2009). Therefore, investigating the reciprocal associations between PA and depression is of high relevance for adults from the general population (Lindwall, Larsman, & Hagger, 2011).

Theories of PA engagement and its maintenance agree that PA is related to complex negative and positive emotions which may form either antecedents or consequences of PA engagement (Ekkekakis, Hall, & Petruzello, 2008; Fredrickson & Joiner, 2018). Despite mounting evidence of significant associations between PA, positive emotions, and negative emotions, the order in which these three variables operate is unclear. Further prospective and reciprocal research investigating relationships between emotions and health-related behaviors are needed (Fredrickson & Joiner, 2018).

What is the order in which PA and emotional symptoms of depression operate? Firstly, PA may predict depression. Low PA levels are considered as modifiable risk factor for depression (Warburton, Nicol, & Bredin, 2006). People who participate in moderate-to-vigorous PA (MVPA) regularly, are at a 45% lower risk for depressive disorder (Warburton et al., 2006). Clinical trials indicated regular PA as a

* Corresponding author.

** Corresponding author. Wroclaw Faculty of Psychology, SWPS University of Social Sciences and Humanities, 30b Ostrowskiego Street, 53-238, Wroclaw, Poland.

E-mail addresses: mkruk@swps.edu.pl (M. Kruk), kzarychta1@swps.edu.pl (K. Zarychta), khorodyska@swps.edu.pl (K. Horodyska), mbaurska@swps.edu.pl (M. Boberska), urte.scholz@psychologie.uzh.ch (U. Scholz), theda.radtke@psychologie.uzh.ch (T. Radtke), aluszczyn@uccs.edu (A. Luszczynska).

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relevant component of interventions for depression symptoms (Warburton et al., 2006). PA influence depression through psychological and physiological pathways (Lindwall et al., 2011). For example, PA reduces the sensitivity of serotonin receptors in brain areas, affects levels of central monoamines, and regulates secretion in hypothalamic-pituitary-adrenal axis (Teixeira et al., 2013).

Secondly, depression may lead to low levels of PA (Lindwall et al., 2011; Roshanaei-Moghaddam, Katon, & Russo, 2009). Theories focusing on cognitive and motivational factors (Ottenbreit, Dobson, & Quigley, 2014) emphasize that individuals with depression tend to avoid behaviors (e.g., PA) perceived as taxing even if they were perceived as pleasant before the onset of depression. This tendency limits positive experiences, reinforces inactivity, and contributes to the onset and maintenance of depression, that in turn prompts even more avoidance and thereby inactivity (Ottenbreit et al., 2014).

Longitudinal studies provided support for either the “MVPA predicts depression” hypothesis (e.g., Lindwall et al., 2011; Lindwall, Gerber, Jonsdottir, Börjesson, & Ahlberg, 2014) or for the “depression predicts MVPA” hypothesis (e.g., Patten, Williams, Lavorato, & Eliasziw, 2009). Systematic reviews of longitudinal studies (Roshanaei-Moghaddam et al., 2009) showed that the baseline levels of depression predicted a decline in MVPA levels at follow-ups. Thus, there is likely a reciprocal relationship of depression and MVPA, but this was tested only once so far (Lindwall et al., 2011). This potentially reciprocal nature of the MVPA-depression relationship highlights the role of emotions as a motivating factor (or a barrier) for future MVPA (Lindwall et al., 2011).

Besides negative emotions, MVPA might be linked to positive emotion variables, such as PA liking (Fredrickson & Joiner, 2018). PA liking refers to an individual's positive emotional response to sport experience (i.e., liking of physical exertion; Scanlan & Simons, 1992). The broaden-and-build theory of positive emotions (Fredrickson, 2013) assumes that positive emotions such as liking build a solid psychological or physical resources, broadening attention and behavioral repertoires. Positive emotions can induce activities which can eliminate the effects of negative emotions (e.g., emotional symptoms of depression) by broadening one's arrays of acceptable behavioral options (Fredrickson, 2013). According to the upward spiral theory of lifestyle change (Fredrickson & Joiner, 2018), positive emotions (such as liking) form the basal mechanism of PA maintenance. Only a few studies analyzed the relationships between MVPA and PA liking (e.g., Brustad, 1993). Longitudinal research supported the “PA liking predicts MVPA” hypothesis (DiLorenzo, Stucky-Ropp, Vander Wal, & Gotham, 1998), but evidence for the “MVPA predicts PA liking” hypothesis is missing. As a majority of studies were conducted in children, it is unclear what patterns of associations may occur among adults.

There is a limited evidence for the associations between emotional symptoms of depression (for brevity called: depression) and PA liking (Abrantes et al., 2017). Therefore, the key question is whether the indicators of emotions are the triggers for changes in the level of MVPA, or whether the reverse direction of associations is true. Thus, we hypothesized that each of the three variables may be a starting point for the ‘MVPA-emotions (depression vs PA liking)’ chain of effects. In particular, we tested: (1) the “depression → PA liking → MVPA” hypothesis (H1), assuming that the indirect effect of depression (Time 1; T1) on MVPA (Time 2; T2) would be mediated by PA liking (T2); (2) the “depression → MVPA → PA liking” hypothesis (H2), assuming that the indirect effect of depression (T1) on PA liking (T2) would be mediated by MVPA (T2); (3) the “PA liking → depression → MVPA” hypothesis (H3), assuming that the indirect effect of PA liking (T1) on MVPA (T2) would be mediated by depression (T2); (4) the “PA liking → MVPA → depression” hypothesis (H4), assuming that the indirect effect of PA liking (T1) on depression (T2) would be mediated by MVPA (T2); (5) the “MVPA → depression → PA liking” hypothesis (H5), suggesting that the indirect effect of MVPA (T1) on PA liking (T2) would be mediated by depression (T2) and finally, (6) the “MVPA → PA liking → depression” hypothesis (H6) suggesting that the indirect effect of MVPA (T1)

on depression (T2) would be mediated by PA liking (T2).

2. Methods

2.1. Participants

At T1, 879 adults (82.9% women) aged 23 to 68 ($M = 36.65$, $SD = 6.10$) took part in the study. The majority of respondents (59.4%) had a normal body mass index (BMI), 2% had a BMI below 18.50, 38.5% had a BMI > 25 indicative of overweight or obesity. At T2 (7–8-month follow-up), data from 603 (68.6%) participants were collected.

Forty percent of participants had a higher education, 29% had a secondary education whereas 5% reported primary education. Most of them declared being employed in full-time (61%) or part-time (16%) jobs, with the remaining 23% reported no current employment or being retired. The majority of participants (56%) indicated that their economic situation was similar to the economic situation of the average family in the country, 33% indicated that their economic situation was better than average; 11% declared that their economic situation was worse than average. Enrolled participants lived in urban (71%) or rural (29%) areas.

2.2. Procedure

Data were collected from 2011 to 2015. Participants were enrolled in 26 locations in general practitioners' offices and schools (among parents attending parent-teacher meetings). Respondents were informed about the study aims and procedures one week before the study began. Next, informed consents were obtained. Participants received personal codes to secure anonymity and filled in questionnaires. This procedure was repeated at T2 (7–8 months after T1), after contacting participants by phone. The attempt to contact individuals was repeated 3–5 times during a three-week period. The following study is a part of a larger study and further details of data collection procedures are presented in Horodyska et al. (2017). The study was approved by the Institutional Review Board at the first author's university.

2.3. Measures

Descriptive statistics for all measures are presented in [Supplementary Table 1](#).

Emotional symptoms of depression at T1 and T2. The Centre for Epidemiological Studies-Depression Scale (CES-D; Radloff, 1977) was developed for use in the general population; it emphasizes the emotional component of depression. CES-D consists of 20 items (“I was bothered by things that usually don't bother me”) with the responses ranging from 1 (never or hardly ever) to 4 (most of the time). Reliability coefficients indicated good internal consistency with Cronbach's α of 0.85 at T1 and 0.83 at T2.

PA liking at T1 and T2. The PA liking was assessed with liking of vigorous PA, liking sports, and PA enjoyment subscales derived from the Child Attraction to Physical Activity Scale (CAPA; Brustad, 1993). In contrast to measures developed for the general population including adults (e.g., Stevens, Moget, de Gref, Lemmin, & Rispen, 2000), CAPA contains items addressing liking of vigorous activity and high exertion. CAPA items do not focus on activities which may be specific for children, and the wording of the majority of items is similar to wording used in scales developed for adults (e.g., Stevens, Moget, De Gree, Lemmink, & Rispen, 2000). Due to the focus on MVPA in the present study, CAPA was used to assessing the emotional experience related to MVPA. The total score of 10 items (e.g., “I don't mind getting out of breath after I exercise hard”) was used. The responses ranged from 1 (never) to 4 (often). The scale had good internal consistency with Cronbach's α of 0.89 at T1 and 0.88 at T2.

Moderate-to-vigorous physical activity at T1 and T2. The Godin Leisure-Time Exercise Questionnaire (Godin & Shephard, 1985) was

used to measure respondents' MVPA. Participants were asked to report their MVPA in the week prior to the study, indicating how often (frequency per week) they engaged in moderate and vigorous exercise for more than 15 min during their free time. To obtain a total metabolic equivalent (MET) score, the vigorous score was multiplied by 9, the moderate score was multiplied by 5, and these two scores were added (Godin & Shephard, 1985). Reliability coefficients indicated moderate internal consistency with Cronbach's α of 0.53 at T1 and 0.59 at T2.

2.4. Data analysis

G*Power calculator was used to determine the sample size. Assuming small effect sizes (expected in non-clinical samples, see Rethorst, Wipfli, & Landers, 2009) at least 770 participants were needed to obtain significant effects ($p = 0.05$, power = 0.85, $f^2 = 0.02$). Two tests were conducted for each dependent variable (DV). However, we decided against using Bonferroni's correction to adjust p levels because it may increase the likelihood of Type 2 error. All missing data (including dropout at T2) were accounted for using full information maximum likelihood. Overall, a total of 31.4% of data were missing across T1 and T2.

Mediation analyses were conducted with PROCESS macro (model 4), 10,000 bootstraps (Hayes, 2013). Two types of coefficients present the results: (1) a regression coefficient for each parameter (see Fig. 1) and (2) the indirect effect coefficient (B) for each indirect pathway between the independent variables (IVs) and DV, accounting for the respective mediators. The IVs in the respective analyses were either depression (T1) (H1 and H2), or PA liking (T1) (H3 and H4), or MVPA (T1) (H5 and H6). As suggested by MacKinnon (2012) each analysis was performed controlling for an effect of a T1 mediator on the respective mediator at T2 as well as a T1 DV on respective DV at T2. Furthermore, we controlled for effects of age and gender on DV at T2. Additionally, to explore the moderating role of gender, two moderated mediation analyses (model 59, PROCESS macro) were conducted for the hypothesized models, yielding significant indirect effects.

3. Results

Preliminary analyses examined attrition and changes over time. Participants who took part in both T1 and T2 did not differ from those who dropped out in terms of age $F(1, 877) = 3.03$, $p = 0.08$, gender $\chi^2(1, 879) = 7.45$, $p = 0.11$, depression, $F(1, 877) = 0.91$, $p = 0.34$, PA liking $F(1, 877) = 1.28$, $p = 0.26$, or MVPA $F(1, 877) = 0.10$, $p = 0.82$. Repeated measures analysis of variance showed no changes over time in depression, $F(1, 878) = 2.028$, $p = 0.155$, $\eta^2 = 0.002$, PA liking, $F(1, 878) = 3.150$, $p = 0.076$, $\eta^2 = 0.004$, or MVPA, $F(1, 878) = 0.288$, $p = 0.592$, $\eta^2 < 0.001$. For correlational analysis see Supplementary Table 1.

The first set of mediation analyses tested indirect effects of depression (T1) acting as the IV, with either PA liking (H1) or MVPA (H2) operating as the mediators. Results (Table 1) showed that the effect of depression (T1) on MVPA (T2) was mediated by PA liking (T2). Participants who reported a higher level of depression at T1 had a lower level of PA liking at T2, which in turn was related to a lower level of MVPA (T2) (see Fig. 1, left panel). In contrast, there was no effect of depression (T1) on PA liking (T2) through MVPA (T2).

The second set of mediation analyses tested indirect effects of PA liking (T1) acting as the IV, with either depression (H3) or MVPA (H4) operating as the mediators. Results (Table 1) indicated that the effect of PA liking (T1) on MVPA (T2) was mediated by depression (T2). Participants who had a higher level of PA liking (T1) had also a lower level of depression (T2), which in turn predicted a higher MVPA level at T2 (see Fig. 1, the right panel). There was no effect of PA liking (T1) on depression (T2) through MVPA (T2).

The final set of mediation analyses examined indirect effects of MVPA acting as the IV, with either depression (H5) or PA liking (H6)

Table 1

Reciprocal relationships between emotional symptoms of depression, PA liking and moderate-to-vigorous physical activity: hypothesized indirect effects and direct effects.

Indirect and direct effects	B	SE	BC 95% CI	
			Lower	Upper
Indirect effects				
<i>Testing the indirect effect of emotional symptoms of depression</i>				
Depression T1 → PA liking T2 → MVPA T2 (H1)	-0.34	0.16	-0.71	-0.07
Depression T1 → MVPA T2 → PA liking T2 (H2)	0.01	0.01	-0.01	0.01
<i>Testing the indirect effect of PA liking</i>				
PA liking T1 → Depression T2 → MVPA T2 (H3)	0.07	0.04	0.01	0.19
PA liking T1 → MVPA T2 → Depression T2 (H4)	< -0.01	< 0.01	-0.01	0.00
<i>Testing the indirect effect of MVPA</i>				
MVPA T1 → Depression T2 → PA liking T2 (H5)	< -0.01	< 0.01	< -0.01	< 0.01
MVPA T1 → PA liking T2 → Depression T2 (H6)	< 0.01	< 0.01	< -0.01	< 0.01
Direct effects				
<i>Direct effects of emotional symptoms of depression</i>				
Depression T1 → MVPA T2	0.45	0.57	-0.67	1.58
Depression T1 → PA liking T2	-0.09	0.03	-0.15	-0.03
<i>Direct effects of PA liking</i>				
PA liking T1 → MVPA T2	1.63	0.42	0.81	2.45
PA liking T1 → Depression T2	-0.04	0.02	-0.08	-0.01
<i>Direct effects of MVPA</i>				
MVPA T1 → PA liking T2	< 0.01	< 0.01	< -0.01	< 0.01
MVPA T1 → Depression T2	< 0.01	< 0.01	< -0.01	< 0.01

Note: Significant values of the unstandardized indirect and direct effect coefficient (B) are presented in bold. Each bootstrap was based on 10'000 repetitions. T1 = Time 1 (baseline), T2 = Time 2 (7–8-month follow-up); depression – emotional symptoms of depression; PA = physical activity; MVPA = moderate-to-vigorous physical activity, H = the hypothesis (1–6).

operating as the mediators. Both analyses yielded non-significant results (see Table 1). Additionally, there were no direct effects of MVPA (T1) on neither depression (T2) nor PA liking (T2).

Additionally, we explored if gender may act as a moderator in the two models which showed significant indirect effects (i.e., models referring to H1 and H3). No moderating effects of gender were found (see Supplementary Table 2; Supplementary Figure 1).

4. Discussion

In response to a call for research on prospective and reciprocal relationships between emotions and health-related behaviors, our study showed that both negative and positive emotions indicators precede MVPA engagement and maintenance in the general population. In contrast, no support was found for the competing models, assuming either that MVPA precedes both negative and positive emotions indicators or that MVPA mediates between negative and positive emotions indicators. These conclusions are drawn for specific indicators of emotions, namely depression and PA liking.

Our study accounted for the interplay between both negative and positive emotions indicators and showed close links between them. The two (negative and positive) emotional responses, chained together, preceded MVPA involvement. The indirect effects suggested that instead of focusing on direct links, future theories emphasizing the roles of positive emotions may need to account for effects and links between negative and positive emotions when explaining MVPA maintenance. For example, it is possible that positive emotions may not only lead to building resources prompting PA (Fredrickson, 2013), but counteract or reduce barriers for PA, such as negative moods.

In line with the broaden-and-build theory of positive emotions

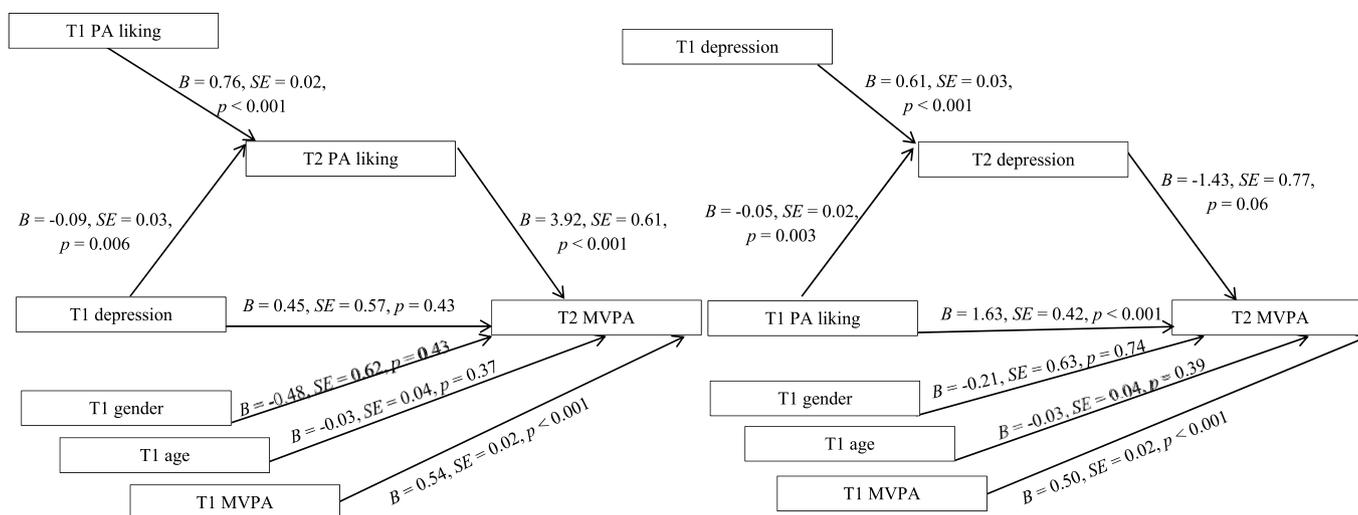


Fig. 1. Associations between emotional symptoms of depression, physical activity liking, and moderate-to-vigorous physical activity (MVPA). Note. T1 = Time 1, baseline; T2 = Time 2, 7–8-month follow-up; H = the hypothesis, PA liking = physical activity liking. Findings referring to H1 are presented in left panel, findings referring to H3 are presented in the right panel. Unstandardized coefficients are reported.

(Fredrickson, 2013) and the upward spiral theory of lifestyle change (Fredrickson & Joiner, 2018) we found that PA liking precede maintenance and engagement in MVPA over a period of 7–8 months. Pleasantness may create nonconscious motives for PA maintenance; these motives grow stronger over time as positive emotions support building psychological and physiological resources which further prompt PA maintenance (Fredrickson & Joiner, 2018).

The findings have relevant implications for psychosocial interventions promoting MVPA engagement and maintenance. PA promotion interventions often focus on environmental, social, and cognitive predictors (Luszczynska et al., 2016). Integration of behavior change techniques which prompt an experience of positive emotions during the initial performance of PA, as well as techniques reducing depressive mood may help to boost the effects of these interventions. Hence, positive emotions have an important role to play in the promotion of MVPA as well as in the prevention of mental illness (Fredrickson, 2013).

A lack of effects of MVPA on depression is not in line with previous research, showing a significant influence of MVPA on a reduction of depressive symptoms (Rethorst et al., 2009). It should be noted that the moderate-size effects of MVPA on depression are observed for clinical populations (Rethorst et al., 2009), whereas our study dealt with the general population. Due to relatively low levels of T1 and T2 depressive symptoms in the general population, there was little room for improvement. In general, only small effects of MVPA on depression in non-clinical populations may be expected (Rethorst et al., 2009).

There were some limitations to the study. The self-report measurement of MVPA might result in biased reports of real activity levels (Lindwall et al., 2014). Thus, future research should use objective measures of PA (e.g., obtained with accelerometers). Yet, the use of accelerometers in large-scale real-world longitudinal research may have low feasibility. Additionally, the reliability and validity of MVPA measure may be considered only acceptable, therefore, the findings need to be treated with caution. Moreover, we used a retrospective self-report measure of PA liking, relying on a recall of emotional experiences associated with past PA experiences. This approach may not fully account for the role of psychophysiological arousal linked to changes in affect during and directly after exercise bouts (Ekkekakis, Hall, & Petruzzello, 2008; Fleig, Lippke, Pomp, & Schwarzer, 2011). Further research, using more complex measures of positive affect and emotional responses to PA, is needed. We focused on specific aspects of positive and negative emotions, hence generalizations regarding other aspects of positive and negative emotions cannot be made. Further, the majority

of participants (83.3%) were women, which could have biased the generalizability of the findings to the general population. Finally, three measurement points would allow for testing the IVs, mediators, and DVs at separate occasions. However, the limitations of our design were counteracted by controlling for the baseline mediator and DVs. Future research should address these limitations. Due to the correlational nature of our design, no causal statements can be drawn. However, given the cross-lagged analyses and the fact that it is impossible to manipulate depressive symptoms, studies like ours are the closest we can get to approaching the question of causal directions.

Concluding, to our knowledge, this is the first study examining the long-term prospective and reciprocal associations between indicators of negative emotions (i.e., depressive symptoms), positive emotions (i.e., PA liking), and levels of MVPA. We found that depression and PA liking were linked together, and preceded subsequent MVPA, thereby explaining MVPA engagement and its maintenance. Emphasizing the role of depression and PA liking may be an important addition to common interventions focusing primarily on self-regulation in interventions promoting PA in adults from the general population.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by Institutional Review Board at the first author's institution.

Informed consent

Participants were asked to provide informed consent about their participation. Participants signed informed consent forms.

Declarations of interest

The authors declare that they have no conflict of interest and no financial interests related to the research to disclose.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.mhpa.2019.03.002>.

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