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# University students' stress and burnout risk: results of an ACT-based online-course using self-assessments and HRV-measurements

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## Abstract

To answer to the need to find effective study-integrated ways to support university students' well-being, an Acceptance and Commitment Therapy (ACT) -based online course intervention was conducted with quasi-experimental waiting-list control group design. Our aim with this study was to provide new knowledge of the relations and changes in students' self-assessed and physiological indicators of well-being and study ability during the course. Participating students ( $N=68$ ) completed self-assessments of psychological flexibility, organised study skills, study-related burnout risk, and perceived stress, and part of them ( $n=35$ ) participated in heart rate variability (HRV) measurements at the beginning and the end of the course. The results showed that students' psychological flexibility and organised study skills increased, as study-related burnout risk decreased in the intervention group with significant Time x Group interaction effects compared to the waiting-list control group. Students' perceived stress decreased in the intervention group, but the Time x Group interaction was not significant. The Time x Group interaction effects of HRV measurements were not statistically significant. The findings of this study indicate that study-integrated ACT-based online course can be effective in supporting university students' psychological flexibility and organised studying and reducing burnout risk, thus contributing to highly needed research on ways to enhance students' well-being in higher-education.

**Keywords** Psychological flexibility · Stress · Heart rate variability · Study-related burnout risk · University students · Online course

## Introduction

Higher education is a demanding context, where students are required to have a wide range of study-related abilities, as well as social and emotional skills needed in the demanding workforce. At the same time, the increase in students' psychological distress and mental health problems is a significant and growing concern (Auerbach et al., 2018). This

discrepancy between the demands and strain highlights the importance of studying and developing study-integrated solutions that can support students' well-being related skills. Psychological flexibility is a concept that refers to an adaptive capability to be in contact with the present moment and to persist in behaviour that serves individuals with valued objectives (e.g., Hayes et al., 2006). The significance of psychological flexibility has increased as a research topic in recent decades, and its importance for psychological well-being and performance has been shown in many studies in several contexts (Hayes et al., 2012; Bond et al., 2013; Kashdan & Rottenberg, 2010; Levin et al., 2017). The basis of the concept is in the Acceptance and Commitment Therapy (ACT), which is a third-wave behaviour therapy intervention that aims to increase psychological flexibility through mindfulness, acceptance, and value-driven behaviour change (Hayes et al., 2006). Even though the background of psychological flexibility is in a therapy context, it has been shown that ACT-based interventions delivered by a variety of non-therapists such as trained researchers

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and teachers can also effectively address psychological distress and increase health behaviours (Arnold et al., 2022). Implications for utilising ACT in educational settings are supported by the notion that it works as a unified model of behavioural change and personal development across a broad range of problems and growth (Hayes et al., 2012) and that enhancing psychological flexibility during studies can prevent students' later psychological distress (Levin et al., 2014). ACT interventions in higher education have been found to increase several aspects of students' self-assessed well-being (e.g. Katajaviuri et al., 2021; Räsänen et al., 2016), but there is a lack of knowledge of the psychophysiological effects of ACT-based interventions. In this study, we sought to meet this need for new knowledge of the effectiveness of a study-integrated intervention course to enhance university students' well-being by examining the effects of an ACT-based online course through the changes in students' self-assessed psychological flexibility, perceived stress, study-related burnout risk, and heart rate variability (HRV).

## Theoretical framework

According to the demands-resources model, different kinds of job- or study-related psychological, physical, social or organisational demands and resources are associated with the experienced strain and motivation (Bakker & Demerouti, 2007). The demands of studying require students' efforts that are related to psychological and physiological costs (Bakker & Demerouti, 2007). When these demands exceed the adaptive capacity of a student, it can lead to prolonged stress (Cohen et al., 2016), which can predispose to problems in well-being and increase the risk of burnout (Maslach et al., 2001). Study-related burnout is a syndrome that can be described as an overall construct of three dimensions: emotional exhaustion, development of a cynical and detached attitude towards one's studying and feelings of inadequacy as a student (Salmela-Aro & Read, 2017; Schaufeli et al., 2002). Burnout has been shown to have detrimental and longitudinal effects on students' well-being (Salmela-Aro & Upadyaya, 2014), thus indicating that preventing prolonged stress and burnout risk in the educational context is important.

Concerning the factors that could prevent students' stress and burnout risk, it is noticeable that different external factors can lead to different outcomes depending on individuals' resources, such as optimism or self-efficacy (Xanthopoulou et al., 2007). These personal resources, defined as psychological characteristics that are associated with the ability to behave and impact one's environment successfully, can have direct impacts or mediate and moderate

well-being-related outcomes of different job- or study-related resources and demands (Schaufeli & Taris, 2014). A personal resource that has been shown to be a significant factor for well-being and performance in several contexts is psychological flexibility, which refers to an ability to be in contact with the present moment, to perceive and accept the thoughts and feelings experienced and to act purposefully following one's values (Hayes et al., 2006; Bond et al., 2013). In other words, psychological flexibility is an adaptive capability to commit to a valued behaviour, despite different thoughts or feelings that may be related to situations (Kashdan & Rottenberg, 2010). The basis of the concept is in ACT, which uses acceptance, mindfulness, commitment and behaviour change processes that have a general goal of increasing psychological flexibility (Hayes et al., 2006). Previous studies have shown that psychological flexibility is related to stress (Hayes et al., 2006), lower study-related burnout risk (Asikainen & Katajaviuri, 2023; Frögéli et al., 2016), and students' better abilities to manage study-related time and effort (Asikainen, 2018; Asikainen et al., 2019; Katajaviuri et al., 2021). Organised study skills, that can be defined as students' ability to self-regulate and manage time and the tasks related to everyday studying (Entwistle & McCune, 2004), have also been shown to be related to university students' study-related burnout risk (Asikainen et al., 2020). Concerning these findings, psychological flexibility and organised study skills can be seen as personal resources that can reduce students' study-related strain.

## ACT-based intervention studies and stress in higher education

When thinking about stress in an educational context, it is noticeable that the phenomenon does not limit only to students' study-related strain. A study with a large cross-national sample ( $n=20\,842$ ) showed that college students' stress can be related to multiple domains of life, such as their financial situation, health and different kinds of social aspects and relationships, and the perceived stress in these different domains predicted mental health problems (Karyotaki et al., 2020). As stress is inevitable in studying and human life, and the impact of stress is partly related to the perception of the stressfulness of events (Cohen et al., 1983; Lazarus & Folkman, 1987), psychological abilities to face and manage stress are important not only for successful studying but for overall well-being and functioning in everyday life. Because the number of students experiencing distress is significant and growing (Auerbach et al., 2018), educational institutions must find ways to answer this challenge and ways to prevent prolonged stress. Behaviour therapy applying online interventions provide for example an

opportunity to access interventions also from distance and have been proven to be effective for wide range of challenges (Andersson, 2010). Meta-analyses of online interventions have showed that ACT can be effectively delivered in a self-guided online format to target a wide range of mental health concerns (Klimczak et al., 2023), and guided cognitive behaviour therapy (CBT) was found equivalently effective in face-to-face versus online guided form for different psychiatric and somatic disorders (Carlbring et al., 2018). In their systematic review and meta-analysis Amanvermez and others (2020) found a small, but significant pooled effect size of different approaches, such as CBT, third wave (including ACT), stress management skills, and mind-body interventions (such as biofeedback) applying self-guided stress management interventions for college students.

In the recent years, ACT-based intervention studies aimed to enhance different aspects of college and university students' well-being have been implemented both online, face-to-face, and as a combination of these. In a study of Canadian university students Grégoire and others (2018) reported greater psychological flexibility, well-being, and school engagement as well as lower stress, anxiety, and depression symptoms after students had participated in a four-week face-to-face group intervention. In a four-week online intervention with US college students, Levin and others (2017) reported significant increases during the course in students' well-being, which were mediated by the changes in students' acceptance and valued living. In their four-week online intervention of Australian university students, Viskovich and Pakenham (2020) reported significant positive changes in participants' stress, depression, anxiety, well-being, self-compassion, life satisfaction, and academic performance, which were mediated by the changes in three or more processes of psychological flexibility (acceptance, cognitive fusion, education values, valued living, and present moment awareness). All intervention gains were maintained at 12-week follow-up. Räsänen and others (2016) reported that a seven-week combined online and face-to-face intervention with Finnish university students resulted in significant gains in students' well-being, life satisfaction, and mindfulness skills alongside significantly reduced stress and depression symptoms. Treatment gains were maintained at a 12-month follow-up. In another study of Finnish university students by Katajavuori and others (2021), an eight-week online intervention course showed that participating students' well-being, psychological flexibility, and time management skills improved, and self-assessed stress levels decreased significantly after participating the course intervention. These results indicate that ACT-based interventions applied in educational settings have various positive effects on different self-assessed aspects of students' well-being, and personal resources in both online and face-to-face

settings, but the research concerning psychophysiological changes during interventions is still scarce.

As stress depends on many different domains, and what a student perceives to be stressful is individual, the connection between psychological flexibility and well-being can be related to several behavioural, psychological, and physiological aspects. In their review, Kashdan and Rottenberg (2010) conclude that people with higher levels of psychological flexibility are more able to self-regulate and face stressful situations due to a receptive attitude to emotions and thoughts because trying to avoid these experiences takes a lot of attentional capacity and narrows the abilities to adapt their behaviour in a purposeful manner. When facing a stressful situation, the experiences of perceived stress can include several components, such as loss of control, feelings of overwhelm or anxiety (Epel et al., 2018). These perceived feelings of distress and negative emotions trigger physiological stress responses (Cohen et al., 2016; McEwen, 1998) that can be observed by HRV. HRV refers to the fluctuation in the time intervals between heartbeats (Malik, 1996) and is generated by the interaction between the heart and the brain via neural pathways of the sympathetic ('fight or flight') and parasympathetic ('rest and digest') branches of the autonomic nervous system (Shaffer et al., 2014). Higher variation in HRV reflects typically more efficient autonomic regulation and the dominance of a parasympathetic nervous system (Shaffer et al., 2014). Lower levels of parasympathetic activity reflecting HRV have been shown to be associated with stress (e.g., Kim et al., 2018). Lower levels of parasympathetic activity reflecting HRV have also been shown to be associated with students' psychological inflexibility (Lim et al., 2022) and students' inability to accept negative emotions (Visted et al., 2017), but to the best of our knowledge, there are still no studies of the effects of ACT-based interventions on students' HRV in higher education. To gain new knowledge of the effects of ACT-based interventions on students' well-being, more research utilising both self-assessments and psychophysiological measurements in ecologically valid settings is needed. In this study, we sought to face this need by examining the effects of an intervention course aiming to support university students' well-being with psychological flexibility training and organised study skills.

## Present study

The aim of this study is to explore the effects of an ACT-based online intervention course on students' psychological flexibility, organised study skills, perceived stress, study-related burnout risk, and HRV. Because individuals' responses to stress vary significantly (McEwen, 1998) and

manifest on social, psychological, and physiological levels (Epel et al., 2018), in this study, students' stress is examined both by their self-assessments of perceived stress and the changes in their HRV. The research questions are: (1) How are students' psychological flexibility, organised study skills, perceived stress, study-related burnout risk and HRV related? (2) How do students' psychological flexibility, organised study skills, perceived stress, study-related burnout risk, and HRV change after participating in the intervention course, and are there differences in the changes between the groups?

Based on previous research, our first research hypothesis was that psychological flexibility is related to lower levels of perceived stress and study-related burnout risk, and higher levels of organised study skills (Asikainen et al., 2019; Hayes et al., 2006; Katajavuori et al., 2021) and that a higher fluctuation of parasympathetic activity reflecting HRV is related to higher levels of students' psychological flexibility (Lim et al., 2022; Visted et al., 2017) and lower levels of perceived stress (Kim et al., 2018; Tripska et al., 2022) and study-related burnout risk (May et al., 2016). To our knowledge, no previous studies have been conducted on the relation of organised study skills, or time-management skills and students' HRV, but as HRV has been shown to be related to self-regulation (Holzman & Bridgett, 2017), we hypothesised that the relation between organised study skills and parasympathetic activity reflecting HRV is positive. The second hypothesis was that the students in the intervention group will report higher levels of psychological flexibility and organised study skills as well as lower levels of perceived stress and burnout risk at the end of the intervention course (Frögéli et al., 2016; Grégoire et al., 2018; Katajavuori et al., 2021; Räsänen et al., 2016), compared to the waiting-list control group. We also hypothesised that these changes are reflected as an increase in students'

parasympathetic nervous system activity indicating HRV, compared to the waiting-list control group.

## Method

### Procedure and participants

As several personal or study-related factors can be perceived as stressful or burdensome by different individuals, the ACT-based intervention course of this study aimed to provide students an opportunity to learn individual well-being-enhancing skills as part of their studies alongside supporting their commitment to utilise them. The optional eight-week online course (3 ECTS) was offered to the students at the University of Helsinki. The course included five weeks of ACT-based exercises that were conducted with an online program called 'Shift Your Stress' (headsted.fi), alongside time management tasks, study skills exercises and reflective peer-evaluated reports (see Table 1). The course in the present study is an earlier version of a course design that is described in more detail in Asikainen & Katajavuori (2021).

The students were recruited to participate in the course via university study program leaders and teachers. The eight-week online course intervention was conducted with quasi-experimental waiting-list control group design, and conducted twice in the autumn of 2019 in the first (August–October) and in the second (October–December) teaching period. A total of 104 students signed up for the courses, of which 58 chose to enroll to the first, and 46 to the second course. The participants in the first course formed the intervention group, and the participants in the second the waiting-list control group. The groups were not randomised. All students answered to self-assessment questionnaires at the beginning and at the end of the course, and part of them participated also in HRV recordings (1–3 days) at the beginning

**Table 1** Structure of the ACT-based online course

Week	Measurements	Theme	Assignments	Reflection	Feedback
1	Self-assessments, HRV	Introduction to the course & orientation to ACT	Time management task		
2		Meaning of values	Time management task		
3		Mindfulness	Exercises related to mindful presence and concentration	Reflective week report	Peer feedback
4		Defusion, well-being and recovery	Exercises related to cognitive defusion, and well-being	Reflective week report	Peer feedback
5		Study skills and techniques	Material about skills and managing studying	Reflective week report	Peer feedback
6		Acceptance	Exercises related to facing and accepting thoughts	Reflective week report	Peer feedback
7		Committed action	Engaging in value-based behavior	Reflective week report, Online group discussion	Peer feedback
8	Self-assessments, HRV	Summary of the course		Reflective learning report	Giving course feedback

and at the end of the course. The waiting-list control groups students participated in the self-assessments and HRV measurements at the same time as the intervention group in the first teaching period, and later participated in the implementation of the course in the second teaching period. A total 68 of the students completed the course, responded to all self-assessment questionnaires, and gave consent to participate in the study (see Fig. 1). The final number of students in intervention group was 35 (age  $M=26.37$ , median=24,  $SD=6.45$ , 85.7% female), and 33 in the waiting-list control group (age  $M=25.70$ , median=24,  $SD=5.28$ , 84.8% female). In the subgroup of students with both HRV and self-assessment measurements, 16 students represented the intervention group (age  $M=26.25$ , median=24,  $SD=7.48$ , female 93.8%) and 19 the waiting-list control group (age  $M=26.21$ , median=24,  $SD=5.83$ , female 89.5%).

According to independent samples  $t$ -test and Chi-square test, the distribution of age or gender did not differ statistically significantly between the intervention and waiting-list group in the whole sample of students, or in the subgroups of HRV measurements participating students.

### Measures and analysis

The students answered self-assessment questionnaires in the beginning and at the end of the intervention course. Psychological flexibility was measured on a scale of 1–5 (1=totally disagree, ..., 5=totally agree) with the seven item Work-related Acceptance and Action Questionnaire (WAAQ) (Bond et al., 2013), adapted for universities (e.g., ‘My thoughts and emotions do not create an obstacle to studying.’) (Asikainen, 2018). The perceived stress of the

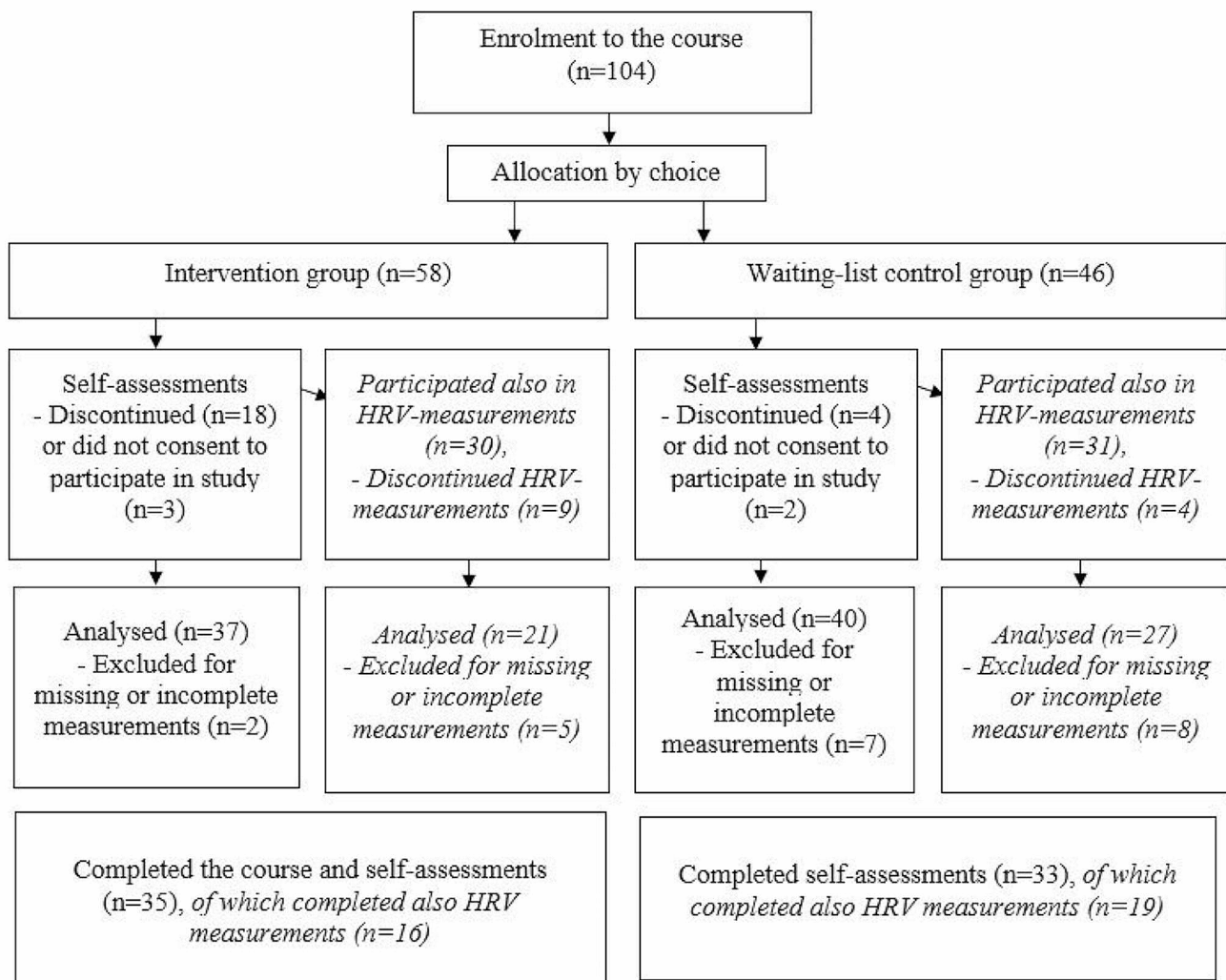


Fig. 1 Participant flow-chart

participants was measured on a scale of 0–4 (0 = never, ..., 4 = very often) by the 10-item Perceived Stress Scale (PSS) (e.g., ‘In the last month, how often have you felt nervous and stressed?’) (Cohen et al., 1983). The measurement of organised study skills was done on a scale of 1–5 (1 = completely disagree, ..., 5 = completely agree) with the questions of HowULearn relating to organised studying (Parpala & Lindblom-Ylänne, 2012; modified from the ALSI, Entwistle et al., 2003). Study-related burnout risk was measured on a scale of 1–6 (1 = completely disagree, ..., 6 = completely agree) using the nine-item Study Burnout Inventory (SBI-9) (e.g., ‘I feel overwhelmed by studying’) (Salmela-Aro & Read, 2017). Only six participants had a maximum of one missing value per self-assessment measure; therefore, missing values were replaced with the individuals’ mean of the measure. The reliability of the measures was analysed by Cronbach’s alpha. In this study, WAAQ ( $\alpha_1 = .89$ ,  $\alpha_2 = .93$ ), ORG ( $\alpha_1 = .75$ ,  $\alpha_2 = .76$ ), PSS ( $\alpha_1 = .90$ ,  $\alpha_2 = .91$ ), and SBI-9 ( $\alpha_1 = .84$ ,  $\alpha_2 = .89$ ) had good reliability coefficients on both measurement times of the study. No outliers were found after visual inspection of the self-assessment data.

The HRV recordings were conducted with a Firstbeat Bodyguard 2 measurement device (Firstbeat Technologies Ltd, Jyväskylä, Finland). The device records the R-R intervals that refer to the time elapsed between two successive R-waves of the QRS signal on the electrocardiogram (Lanfranchi & Somers, 2010). These R-R interval data are scanned through an artefact detection filter, followed by an initial correction of falsely detected or missed heartbeats (Parak & Korhonen, 2013). The corrected R-R intervals are then re-sampled at a rate of 5 Hz by using linear interpolation to obtain equidistantly sampled time series (Saalasti, 2003). After re-sampling, the software removes low frequency trends and variances below and above the frequency band of interest and calculates values for time domain and frequency domain variables, such as rMSSD and HF power (0.15–0.40 Hz) (Firstbeat Technologies, 2019). Next, the artefact-corrected HRV data provided by Firstbeat were pre-treated by classifying them according to the ID numbers given to the students and adding group, measurement time and various time-classifying variables. The clearly invalid values of the data – such as values where the HF2 Vector = 0, Absolute Stress Vector = 0 or HF2 Vector was over 25,000 but the HR value was missing – were deleted. The observed HRV variables in this study were artefact-corrected heart rate (HR), a parasympathetic activity reflective time domain HRV variable called root mean square of successive differences in R-R intervals (rMSSD) and the frequency domain variable high frequency (HF) power (0.15–0.4 Hz). RMSSD is seen to index vagal tone (Kleiger et al., 2005), as the HF power indexes vagal modulation and is affected by the respiratory sinus arrhythmia (Malik,

1996). The HRV data consisted of 1–3 recorded days at the beginning and at end of the intervention course. The students were instructed to report their working, exercising, sleeping, and alcohol consumption in measurement diaries that also included their age, gender, and BMI. The analysis of the HRV measurements proceeded by tabulating the diaries and Firstbeat’s lifestyle assessment reports of the subjects’ measurement days. As the students worked and studied also during the weekends, all weekdays of the measurement were included in the analysis. Students’ daily activities and their style of labelling them varied significantly. Therefore, it was concluded that night-time ‘sleep’ marked periods, i.e., time spent in bed, were the most comparable time to analyse. The values of HR and HF were retrieved from the second-by-second data, and the sleep-time rMSSD values were retrieved from the Firstbeat’s lifestyle assessment professional reports. As alcohol affects the results of HRV measurements (Laborde et al., 2017), the measurement days during which the subjects reported having consumed more than one alcohol dose were excluded from the analysis. One of the participants in the intervention group was classified as a potential outlier because the means of both measurements of HF exceeded the standard span of 1.5 times the interquartile range (IQR) from the median. Results of a paired sample *t*-test showed that, without this possible outlier, the *p*-value remained almost the same ( $p = .576$ ) and the effect size was slightly higher ( $d = 0.12$ ) than with this ID ( $p = .581$ ,  $d = 0.09$ ). Because of the small difference and the limited number of participants, this ID was included in the analysis. The correlations between the variables were analysed with Pearson’s correlation coefficient (*r*). The effect of Time, Group, and Time  $\times$  Group interaction effects were explored by mixed design ANOVA with repeated measures, with Bonferroni adjustment for multiple comparisons with alpha level of 0.05 and Partial Eta Squared ( $\eta^2_p$ ) as the effect size. Because the measurements of HF were not normally distributed in the intervention group, the difference in changes between the measurement times and groups was revised using change variables and Kruskal-Wallis. Analysis of the data was undertaken by RStudio (version 4.0.5) and SPSS (version 27).

## Results

### Relationships between the variables in the study

Examination of the correlations between the self-assessments showed that psychological flexibility was significantly related to lower scores in perceived stress and study-related burnout risk in both measurement times in the intervention and control group. Perceived stress had a statistically

significant correlation with higher scores in burnout risk in both measurement times in both groups. Organised study skills correlated positively with psychological flexibility, and negatively with perceived stress and burnout risk. In the intervention group, organised study skills correlated significantly in the beginning measurements, but not in the second. The negative correlations between organised study skills and perceived stress and burnout risk were not statistically significant in the waiting-list control group. HR correlated negatively in a statistically significant way with parasympathetic nervous system activity reflecting rMSSD and HF in both groups in both measurement times. In the intervention group, lower rMSSD and HF scores had a statistically significant correlation to higher perceived stress in both measurement times, and the association between study-related burnout risk and lower HF was significant in the second measurement time. In the control group, no statistically significant correlations between the HRV and self-assessments were seen (see Table 2).

### Differences in the measurement times within and between groups

Table 3 displays the descriptive statistics of the students' measurements at the beginning and at the end of the course. The results of the mixed ANOVA with repeated measures showed that the Time x Group interaction was statistically significant on psychological flexibility ( $F(1, 64)=4.46$ ,  $p=.039$ ,  $\eta^2_p=0.07$ ), organised study skills ( $F(1, 64)=9.49$ ,  $p=.003$ ,  $\eta^2_p=0.13$ ), and study-related burnout risk ( $F(1, 64)=5.09$ ,  $p=.027$ ,  $\eta^2_p=0.07$ ), indicating that the changes

in these differed in the intervention and waiting-list control group (Table 4).

The pairwise comparisons showed that psychological flexibility increased significantly in the intervention group between the measurements ( $F(1, 64)=10.62$ ,  $p=.002$ ,  $\eta^2_p=0.14$ ). The mean of psychological flexibility remained almost the same between measurement times in the waiting-list control group, and the change was not statistically significant. The measurements of psychological flexibility at the beginning of the course did not differ significantly between intervention and waiting-list control group ( $F(1, 64)=1.79$ ,  $p=.185$ ,  $\eta^2_p=0.10$ ), thus the statistically significant main effect of group ( $F(1, 64)=4.46$ ,  $p=.039$ ,  $\eta^2_p=0.07$ ) was due to the difference between the groups in the second measurements at the end of the intervention course ( $F(1, 64)=6.73$ ,  $p=.012$ ,  $\eta^2_p=0.10$ ). The pairwise comparison of changes in organised study skills showed that organised study skills increased significantly in the intervention group ( $F(1, 64)=16.42$ ,  $p<.001$ ,  $\eta^2_p=0.20$ ). In the waiting-list control group, students' organised study skills decreased slightly, but the changes were not statistically significant. The pairwise comparison of changes in study-related burnout risk showed that burnout risk decreased significantly in the intervention group between the measurement times ( $F(1, 64)=4.67$ ,  $p=.034$ ,  $\eta^2_p=0.07$ ). In the waiting-list control group, students' burnout risk increased slightly, but the changes were not statistically significant.

The mean of perceived stress decreased in the intervention group, and increased in the waiting-list control group, but the Time x Group interaction effect was not statistically significant ( $F(1, 64)=3.94$ ,  $p=.052$ ,  $\eta^2_p=0.06$ ). The

**Table 2** Correlations of intervention and waiting-list control groups self-assessments and HRV

Intervention group			WAAQ	ORG	PSS	SBI	HR	rMSSD	HF
WAAQ	n								
WAAQ	35	<i>r</i>	-	0.30	-0.60***	-0.58***	-0.03	0.05	-0.07
ORG	35	<i>r</i>	0.45**	-	-0.34*	-0.45**	0.16	0.05	0.25
PSS	35	<i>r</i>	-0.59***	-0.37*	-	0.71***	0.45	-0.61*	-0.55*
SBI-9	35	<i>r</i>	-0.71***	-0.52**	-0.638***	-	0.18	-0.37	-0.50*
HR	16	<i>r</i>	-0.22	-0.10	0.50*	0.18	-	-0.92**	-0.75***
rMSSD	16	<i>r</i>	0.28	0.23	-0.57*	-0.34	-0.87***	-	0.92***
HF	16	<i>r</i>	0.26	0.27	-0.50*	-0.40	-0.75***	0.95***	-
Waiting-list control group									
WAAQ	n								
WAAQ	33	<i>r</i>	-	0.58***	-0.67***	-0.70***	-0.05	0.10	0.13
ORG	33	<i>r</i>	0.35*	-	-0.27	-0.21	-0.07	-0.05	-0.08
PSS	33	<i>r</i>	-0.73***	-0.19	-	0.80***	-0.12	0.20	0.17
SBI-9	33	<i>r</i>	-0.70***	-0.34	0.71***	-	0.35	-0.27	-0.21
HR	19	<i>r</i>	-0.18	-0.34	0.11	0.32	-	-0.77**	-0.63*
rMSSD	19	<i>r</i>	0.16	-0.01	-0.12	-0.25	-0.64**	-	0.94***
HF	19	<i>r</i>	0.12	-0.05	-0.10	-0.16	-0.55*	0.95***	-

Note Pearson's correlation coefficients of groups' first measurement (below diagonal) and second measurement (above diagonal). WAAQ=psychological flexibility, ORG=Organised study skills, PSS=perceived stress, SBI-9=study-related burnout risk, HR=heart rate, rMSSD=root mean square of successive differences in R-R intervals, HF=high frequency (0.15–0.4 Hz) power. Significance level \* $p<.05$ , \*\* $p<.01$ , \*\*\* $p<.001$

**Table 3** Descriptive statistics of the intervention and waiting-list control groups measurements at the beginning and at the end of the intervention course

Whole sample ( $N=68$ )							
	Intervention group			Waiting-list control group			
	n	M1 (SD)	M2 (SD)	n	M1 (SD)	M2 (SD)	
WAAQ	35	3.14 (0.68)	3.44 (0.77)	33	2.86 (0.86)	2.87 (0.94)	
ORG	35	2.96 (0.92)	3.46 (0.82)	33	3.01 (0.78)	2.94 (0.80)	
PSS	35	1.47 (0.64)	1.32 (0.64)	33	1.75 (0.88)	1.78 (0.77)	
SBI-9	35	3.14 (1.00)	2.89 (1.01)	33	3.38 (1.01)	3.49 (1.08)	
<i>Subgroup with also HRV (<math>n=35</math>)</i>							
WAAQ	16	2.92 (0.67)	3.15 (0.74)	19	2.81 (0.71)	2.80 (0.80)	
ORG	16	3.05 (1.01)	3.56 (0.76)	19	3.00 (0.66)	2.87 (0.66)	
PSS	16	1.55 (0.67)	1.47 (0.63)	19	1.64 (0.82)	1.54 (0.72)	
SBI-9	16	3.33 (0.90)	2.61 (0.92)	19	3.32 (0.77)	3.35 (1.02)	
HR	16	61.61 (5.86)	63.00 (6.61)	19	59.63 (5.17)	61.07 (6.50)	
rMSSD	16	53.64 (23.75)	49.52 (22.72)	19	57.82 (19.90)	53.05 (17.97)	
HF	16	2815.15 (2106.65)	2615.91 (2095.27)	19	3232.99 (1891.69)	2709.38 (1488.83)	

*Note* M1 = Mean at the beginning of the course, M2 = Mean at the end of the course, SD = Standard deviation, WAAQ = psychological flexibility, ORG = Organised study skills, PSS = perceived stress, SBI = study-related burnout risk, HR = heart rate, rMSSD = root mean square of successive differences in R-R intervals, HF = high frequency (0.15–0.4 Hz) power

pairwise comparisons showed that the beginning means of perceived stress did not differ in statistically significantly between the intervention and waiting-list control group, and hence the significant main effect of group ( $F(1, 64) = 5.26$ ,  $p = .025$ ,  $\eta^2_p = 0.08$ ) was due to the difference between the groups in the second measurements at the end of the intervention course ( $F(1, 64) = 8.87$ ,  $p = .004$ ,  $\eta^2_p = 0.12$ ). However, as indicated by the significant Time x Group x HRV effect ( $F(1, 64) = 4.45$ ,  $p = .039$ ,  $\eta^2_p = 0.07$ ), the changes in students' perceived stress differed within these groups. In the intervention group perceived stress decreased both with students that had participated in HRV measurements, and with students who had not, but the decrease was significant only within the latter group ( $F(1, 64) = 4.64$ ,  $p = .035$ ,  $\eta^2_p = 0.07$ ). In the control group perceived stress decreased in the group of students that had participated in HRV measurements and increased in the group who had not. Students' HR increased slightly, and the means of rMSSD and HF decreased in both intervention and waiting-list group. No significant main effect of time, group or interaction between the measurement time and group were to be seen in the HRV measurements. The mean differences of the self-assessments and HRV measurements are shown in Figs. 2 and 3.

## Discussion

The aim of this study was to explore the relations and changes in the psychological flexibility, organised study skills, study-related burnout risk, perceived stress, and HRV of university students who participated in an ACT-based online intervention course, and to compare these changes to the changes in the waiting-list control group. The results

indicated that the online course intervention had positive effects on different self-assessed factors of well-being, as intervention-participating students' study-related burnout risk decreased and psychological flexibility and organised study skills increased, with opposite changes in the control group.

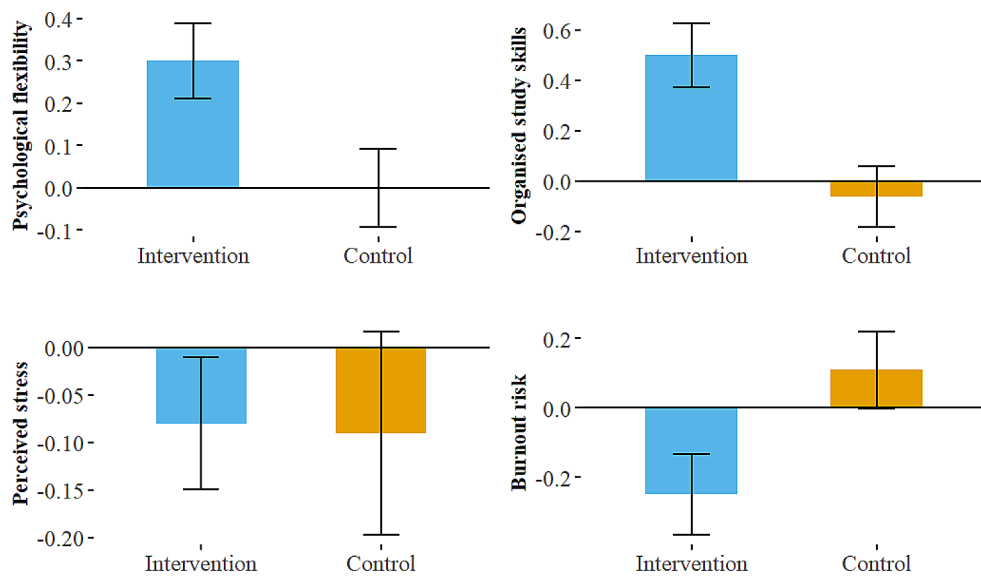
The first research question of this study was: How are students' psychological flexibility, organised study skills, perceived stress, study-related burnout risk, and HRV related? The results that psychological flexibility had a negative relation to perceived stress and study-related burnout risk, and that the relation between perceived stress and burnout risk was positive were in line with earlier findings (Asikainen et al., 2019; Bond et al., 2013; Hayes et al., 2006; Katajaviuori et al., 2021). Organised study skills were positively related to psychological flexibility, and negatively to burnout risk and perceived stress, as also shown in previous studies (Asikainen, 2018; Asikainen et al., 2019, 2020; Katajaviuori et al., 2021). The positive correlations between HRV variables rMSSD and HF were significant, and both variables correlated negatively with HR, confirming earlier findings that lower heart rate is related to higher levels of parasympathetic activity (Shaffer et al., 2014). The results concerning the relations between self-assessments and HRV showed that lower levels of parasympathetic activity reflecting rMSSD and HF were significantly related to higher level of perceived stress in the intervention group, but not in the waiting-list control group. Based on a visual inspection of the relationships between the means of HRV and the self-assessments in the waiting-list, we found influential observations that had below average means of psychological flexibility and organised study skills, and above average means of perceived stress, and rMSSD and HF at

**Table 4** Results of the mixed ANOVA with repeated measures

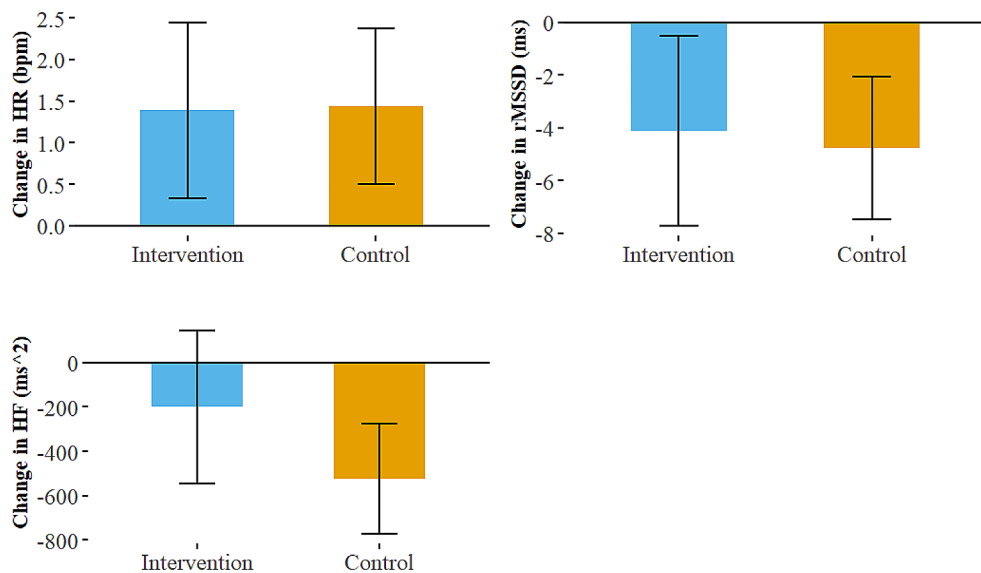
Self-assessments (N=68)	WAAQ			ORG			PSS			SBI						
	df	F	p	$\eta^2_p$	df	F	p	$\eta^2_p$	df	F	p	$\eta^2_p$	df	F	p	$\eta^2_p$
<i>Between-subjects effects</i>																
Group	1	4.46	<b>.039</b>	0.07	1	1.61	0.209	0.03	1	5.26	<b>0.025</b>	0.08	1	3.21	0.078	0.05
HRV	1	2.63	0.110	0.04	1	0.031	0.862	0.00	1	0.37	0.545	0.01	1	0.25	0.619	0.00
Group x HRV	1	0.77	0.383	0.01	1	0.52	0.474	0.01	1	3.33	0.073	0.05	1	2.38	0.128	0.04
Error	64				64				64				64			
<i>Within-subjects effects</i>																
Time	1	5.38	<b>0.024</b>	0.08	1	6.46	<b>0.013</b>	0.09	1	0.64	0.428	0.01	1	0.55	0.460	0.01
Time x Group	1	4.84	<b>0.031</b>	0.07	1	9.49	<b>0.003</b>	0.13	1	3.94	0.052	0.06	1	5.09	<b>0.027</b>	0.07
Time x Group x HRV	1	0.09	0.762	0.00	1	0.30	0.584	0.01	1	4.45	<b>0.039</b>	0.07	1	1.92	0.171	0.03
Error(Time)	64				64				64				64			
<i>HRV-measurements (N=35)</i>																
<i>Between-subjects effects</i>																
Group	1	1.04	0.316	0.03	1	0.32	0.573	0.01	1	0.18	0.677	0.01	1			
Error	33				33				33				33			
<i>Within-subjects effects</i>																
Time	1	4.03	0.053	0.11	1	4.02	0.053	0.11	1	3.01	0.092	0.08	1			
Time x Group	1	0.00	0.971	0.00	1	0.02	0.884	0.00	1	0.61	0.442	0.02	1			
Error(Time)	33				33				33				33			

Note WAAQ=psychological flexibility, ORG=Organised study skills, PSS=perceived stress, SBI=study-related burnout risk, HR=heart rate, rMSSD=root mean square of successive differences in R-R intervals, HF=high frequency (0.15–0.4 Hz) power, df=degrees of freedom,  $\eta^2_p$ =partial eta squared, Time=Time of measurement (at the beginning and end of the intervention course), Group=Intervention/Waiting-list control, HRV=Participation in HRV-measurements (yes/no), Significant p-values highlighted

**Fig. 2** Mean changes in the self-assessment measurements ( $n = 68$ ) at the end of the intervention course



**Fig. 3** Mean changes in the HRV ( $n = 35$ ) at the end of the intervention course



both measurement times. In other words, in the waiting-list control group there were more students who assessed their stress to be high, while assessing their psychological flexibility and organised study skills to be low but had above mean level of parasympathetic activity at the time of HRV measurements. It is also noticeable that although the relation between stress and HRV has been shown in previous studies (Kim et al., 2018), there are also earlier studies that have shown mixed results, such as the connections between HRV and perceived stress has been found to be weak (Martinez et al., 2022). The earlier studies of HRV and work-related burnout have also shown different results, with some indicating no association between elevated levels of burnout related exhaustion and HRV (Thielmann et al., 2021).

The second research question of this study was: How do students' psychological flexibility, organised study skills,

perceived stress, study-related burnout risk, and HRV change after participating in the intervention course, and are there differences in the changes between the groups? The results of mixed design ANOVA with repeated measures showed that the increase in students' psychological flexibility and organised study skills, and the decrease in study-related burnout risk had statistically significant Time x Group interaction effects between the intervention and waiting-list control group and were in line with previous findings (Frögéli et al., 2016; Grégoire et al., 2018; Katajaviuori et al., 2021). Increase in students organised studying during ACT-based course has been reported in a previous study (Katajaviuori et al., 2021), but the effect has not been previously studied in comparison to a control group. The results showed also that perceived stress decreased in the intervention group, but the Time x Group interaction was

not significant. However, the significance was close to significant ( $p = .052$ ), and the partial eta squared indicated a medium effect size ( $\eta^2_p = 0.06$ ). The results also showed that in the waiting-list control group perceived stress decreased slightly with students who had participated in HRV measurements. This decrease in perceived stress of waiting-list control group students could be interpreted to be due to a treatment effect of participating in HRV measurements and being more aware of their behaviour, as writing a diary of their daily activities was part of the measurements also in the waiting-list control group. However, the pairwise comparisons also showed that in the intervention group the decrease in students' perceived stress was significant only within the group of students that did not participate in HRV measurements, indicating an opposite effect.

The results concerning the changes in HRV during the intervention course showed that students' HR increased slightly both in the intervention and the waiting-list control group, but the changes were not statistically significant. When considering the changes in HR, it is noticeable that the first measurements were done at the beginning of the teaching period following the summer break, and the second at the end of October or beginning of November. As there are observations that the resting heart rate of people living in the Northern hemisphere tends to be at the lowest in August, and 2.1 beats per minute higher in December (Koskimäki et al., 2019), the increase in both groups' HR might be partly explained by the seasonal differences (Kristiansen et al., 2009). The results also showed that the means of students' rMSSD and HF decreased in the intervention and waiting-list control group, with the reduction being steeper in the control group. However, no significant interaction of Time  $\times$  Group was found in the changes between the groups. The results of low and varied correlations between parasympathetic nervous system reflecting HRV and self-assessments, and the non-significant changes between the groups in students' HRV in this real-life measurement-utilising study might be due to for example limited number of participants, high variation in students' behaviour and individual HRV, differences in subjective self-assessed well-being related factors and HRV, and different contextual and situational factors, such as time of the semester.

During the course intervention presented in this study, students had an opportunity to reflect on their behaviour through the things that are meaningful to their well-being and studying in their individual situations, and to learn abilities and skills that enable a more open attitude to different kinds of situations and experiences alongside the abilities to commit to a behaviour that is purposeful. The importance of the significant improvement in the course intervention participating students' psychological flexibility and organized study skills alongside decrease in burnout

risk are emphasised by the previous findings, that a wide variety of different personal resources, such as cognitive and motivational resources and socio-emotional skills have been shown to be related not only to lower burnout risk, but also to better engagement in studies (Salmela-Aro et al., 2022). Therefore, the opportunity to enhance their personal resources such as psychological flexibility, and organised way of studying in a study-integrated ACT-based course can be valuable resources for students to adapt and engage in valued behaviour and balance the strain from the different demands of studying.

## Limitations and further directions

Although the results of the present study showed positive effects of ACT-based course intervention in enhancing students' self-assessed aspects of well-being related factors, several limitations should be mentioned. First, although the compared groups were not randomised in this quasi-experimental study, they did not differ in statistically significant way from each other in terms of age, gender, or the beginning measurements of the measured variables. However, the study sample was quite homogeneous, as the participants were mainly young and female. Second, the number of participants in this study was limited, especially concerning the number of participants in the HRV measurements. It has been shown that to achieve 80% power with a medium effect size in between-group studies using HRV measurements, the number of participants in groups should be 61 (Quintana, 2017). A major part of HRV measurement participating students' ( $N = 61$ ) data was lost not only due to discontinuing participation in the measurements ( $n = 13$ ), but also due to missing or incomplete measurements ( $n = 13$ ). Measuring HRV in natural settings is challenging, as what happens in the real life of the students during the measurements is not controlled. A controlled laboratory measurement situation could have produced HRV data with fewer artefacts and data that were easier to compare between subjects (Laborde et al., 2017), but in this present study, the opportunity to study changes during students' everyday life was prioritised. The pursuit to achieve ecological validity by measuring students in natural situations led to significant losses of data, as students attached the measurement devices themselves, and some of the data were missing. Some of the measurement days were also lost due to students reported alcohol use. This may have also left out of the HRV-measurement of for example stressed out students who use alcohol to relieve their emotional distress. Also, when thinking of the changes that can lead to students' better abilities to manage study-related strain, it is noticeable that before and after measured group-level changes do not capture the intra-individual change processes of behaviour, or the contextual

factors that can influence situational stress at the time of the measurement. Third, a lack of follow-up measurements is a limitation, as the changes in students' well-being can appear later than the second measurement at the end of the course, as the ability to accept thoughts in a mindful way, and to pursue behaviour committing to one's values are processes that can take time. As there is a strong connection with perceived stress in different domains of life, and the prevalence of different mental disorders in the student population (Karyotaki et al., 2020), the reductions in perceived stress with part of the students' participating in the course could also potentially prevent later problems. A six-month follow-up measurement of the self-assessments was conducted, but as the number of respondents was small, these results were left out of the analysis.

To increase the reliability and add knowledge of differences in students' HRV during study-integrated intervention courses, future research should continue to use ambulatory HRV recordings on larger samples of students, together with controlled baseline, and follow-up measurement. Also, the differences of the beginning levels of burnout risk on the changes during course intervention should be studied further, alongside studying changes in engagement, and the mediating effects of psychological flexibility and organised study skills on intervention participating students' well-being with a larger sample of students. As Hofmann and others (2020) state, the individual changes during interventions are dynamic processes that can include bi-directional and complex relationships that differ between individuals. These notions emphasise the importance of studying further both the longitudinal and intra-individual changes in course-participating students' well-being by applying, for example, time-intense experience sampling methods together with continuous HRV measurements.

## Conclusions

To conclude, the results of the effects of study-integrated ACT-based online intervention course presented in this study showed that there was a significant reduction in intervention participating students' burnout risk alongside enhancement in their psychological flexibility and organised study skills compared to the waiting-list control group. Despite limitations, these findings show promise of the effects of ACT-based courses on students' personal resources and burnout risk and contribute to highly needed research on how to enhance students' well-being in the higher-education context. As the ACT approach aims to increase well-being by focusing on behaviour in accordance with the individual's values rather than mental symptoms, it is particularly well suited to preventive interventions also in the educational

context (Levin et al., 2014). These premises and the promising results of this study suggest that applying and further developing ACT-based course interventions more widely as part of university studies could be an effective way to support student well-being – also before there are problems. As research applying HRV measurements in educational settings and ACT-based interventions is still scarce, to our knowledge there are not yet any guidelines to follow in this context. As the deeper understanding of the role of psychological flexibility and psychophysiological indicators of stress in educational settings increase, the opportunities to implement and interpret the results of well-being-enhancing intervention courses progress.

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**Data availability** The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Ethical approval** The research has been conducted in accordance with the Declaration of Helsinki guidelines and followed Finnish National Board on Research Integrity's ethical principles for research with human participants.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

**Conflict of interest** The authors declare that there exists no competing financial interest or personal relationships that could have appeared to influence the work reported in this paper.

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