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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

The effect of script-driven imagery of emotions and hyperventilation on center of pressure, trunk muscle activation and end-tidal carbon dioxide during postural control

Charlotte Schrijvers
Sofie Van Wesemael

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen

PROMOTOR :
Prof. dr. Lotte JANSSENS

COPROMOTOR :
Prof. dr. Katleen BOGAERTS

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www.uhasselt.be
Universiteit Hasselt
Campus Hasselt:
Martelarenlaan 42 | 3500 Hasselt
Campus Diepenbeek:
Agoralaan Gebouw D | 3590 Diepenbeek

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“The effect of script-driven imagery of emotions and hyperventilation on center of pressure, trunk muscle activation and end-tidal carbon dioxide during postural control”

We would like to thank our promotor Prof. Dr. L. Janssens, our copromotor Prof. Dr. K. Bogaerts and Dr. Nina Goossens for their valuable time and assistance throughout this process. Likewise we are grateful for Dr. A. Ivanova her excellent help in the statistical analysis and for Dr. R. Baggen for sharing his insights in motion analysis.

Lindeveld 24 3990 Peer, 06/07/2021 C.S.

Oude Luikerbaan 24 3500 Hasselt, 06/07/2021 S.V.W

Context of this master thesis

The main research domain of this master thesis is the musculoskeletal rehabilitation domain. As this master thesis was conducted under the musculoskeletal rehabilitation research group at REVAL, it is closely related to their vision and mission. This research group aims to provide an innovative contribution to the evaluation and treatment of individuals with musculoskeletal conditions by identifying multidimensional mechanisms that might cause musculoskeletal complaints. So this master thesis investigates center of pressure parameters, trunk muscle activity and CO2 levels on one hand, but on the other hand more multidimensional components are included as well, such as psychological trait and state of the participants. Therefore, this research is situated in a more biopsychosocial framework.

It is known that postural control plays a very important role in producing voluntary movements during daily life activities (Bouisset & Zattara, 1983). However, this postural control system can be affected by several factors. First of all, postural control can be influenced by our respiration due to the dual functioning of the diaphragm in both the postural control and the respiration mechanism (Kocjan, Adamel, Gzik-Zroska, Czyżewski, & Rydel, 2017). Secondly, the psychological state of an individual can affect postural control as well. There is a direct effect of psychological factors (Christe et al., 2021), as well as an indirect effect caused by the effect of psychological factors on respiration (Gilbert, 1998). These relationships were closely investigated in the master thesis we wrote last year: '*The influence of psychological factors and dual tasks on postural control in patients with low back pain'.*

The aim of this master thesis is to investigate the influence of induced emotions by means of script-driven imagery, induced hyperventilation by means of a voluntary hyperventilation provocation test and psychological state and trait on center of pressure, trunk muscle activity and end-tidal carbon dioxide in healthy controls during postural control.

This master thesis is part of a running doctoral project of Dra. Charlotte Amerijckx, entitled "Hyperventilation in recurrent non-specific low back pain: a bottom-up and top-down perspective", supervised by Prof. Dr. Lotte Janssens and Prof. Dr. Katleen Bogaerts. A protocol, which this study had to adhere to, was provided by the supervisors. The research was carried out by two master students under supervision of a research team (Prof. Dr. L. Janssens, Prof. Dr. K. Bogaerts, Dr. N. Goossens, Dr. R. Baggen) and took place at the REVAL rehabilitation

research center of Hasselt University. Primary outcome measures, being center of pressure parameters, trunk muscle activity and end tidal carbon dioxide, were obtained using a force plate, EMG electrodes and capnography respectively. Secondary outcome measures, being psychological trait and state, were obtained using electronic questionnaires participants had to fill in before the start and during the measurements. Data was processed using Matlab with assistance of Ir. M. Geraerts and statistical analyses was executed in JMP with assistance of Dr. A. Ivanova of CenStat. This occurred with assistance of Dr. R. Baggen, Prof. Dr. L. Janssens and Dr. N. Goossens. Finally all this information was put together in this paper by two students which resulted in this master thesis part 2.

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1. Abstract

Background: Postural control is an exceedingly complex system, necessary to perform daily life activities. It is influenced by the sensorimotor, cognitive and neurological system. Moreover, psychological factors and breathing appear to affect postural control as well, however, this relationship has not been extensively investigated yet.

Objectives: This study aims to investigate the influence of induced emotions by means of script-driven imagery and induced hyperventilation by means of voluntary hyperventilation on center of pressure (COP), trunk muscle activity (EMG) and end-tidal carbon dioxide (PetCO2) during postural control.

Methods: 21 healthy participants were exposed to three different scripts before and after a hyperventilation provocation test, to induce hostile resistance (HR), acceptance (A) and relaxation (R) emotions. During these scripts, COP, EMG and PetCO2 data were collected in upright standing on a foam without vision. Furthermore, psychological state and trait were obtained by means of questionnaires as secondary outcomes.

Results: COP min values were significantly higher during the HR script compared with the R script ($P < 0.05$), the opposite occurred for COP total sway path values ($P < 0.05$). Additionally, COP total sway path was significantly higher during the R script compared to the A script ($P < 0.05$). No significant effects were found for script on EMG and PetCO2 levels. Furthermore, COP maxvel ML ($P < 0.05$), m. erector spinae activity ($P < 0.05$) and PetCO2 levels ($P < 0.05$) were significantly higher pre-hyperventilation than post-hyperventilation.

Conclusion: Imagery-induced emotions affect COP parameters, however no effect was found on EMG and PetCO2. Voluntary hyperventilation appears to affect all primary outcome parameters, as several COP, EMG and PetCO2 values were higher pre-hyperventilation compared to post-hyperventilation.

Keywords: Postural control, muscle activity, emotion-induced scripts, hyperventilation, psychological factors

2. Introduction

The diaphragm has multiple functions in the human body. Despite being the main inspiratory breathing muscle, it is also involved in controlling intra-abdominal pressure. As the diaphragm contracts, the intra-abdominal pressure increases and so does the stability of the lumbar spine (Hodges & Richardson 1997; Hodges & Gandevia 2000). The influence of the diaphragm on lumbar stability is mainly due to its anatomical characteristics, considering the diaphragm's origin at the lumbar vertebrae (Kocjan, Adamek, Gzik-Zroska, Czyżewski, & Rydel, 2017). This indicates that the functioning of the diaphragm is closely related with postural control, which is necessary to perform daily life activities (Nies & Sinnott, 1991). In addition, postural control is considered a key factor in producing voluntary movements (Bouisset & Zattara, 1983). For example, Hodges, Gurfinkel, Brumagne, Smith and Cordo (2002) observed that an increased demand of inspiration leads to a decrease of postural control, resulting in an increased postural sway. These findings are in accordance with a study of Janssens, Brumagne, Polspoel, Troosters and McConnell (2010) who showed that an increased demand of inspiration resulted in an impaired postural control, due to fatigue of the inspiratory muscles. Malakhov, Makarenkova and Melnikov (2014) observed an increase of velocity and frequency of center of pressure displacements during breath holding. They stated that this diminished postural control might be caused by the strong low-amplitude high-frequency contractions of the respiratory muscles, including the diaphragm, that occur during breath holding. These contractions could cause a strain on the postural control system (Whitelaw, Derenne, Noble, & McBridge, 1988). David, Laval, Terrien and Petitjean (2012) investigated the effect of increased respiratory demand on postural control by means of voluntary and metabolic induced hyperventilation. They concluded that during hyperventilation, postural control was reduced. Considering those results, it is very likely that the diaphragm obtains an essential role in maintaining postural control.

Next to the effect of increased respiratory demand on postural control, the effect of altered breathing patterns on postural control is arising interest as well. There are many possible alterations in breathing patterns, due to higher oxygen demands, psychological factors or induced stress (Gilbert, 1998; Brinkman, Toro, & Sharma, 2020). A possible consequence of an altered breathing pattern is hypercapnia, which is characterised by a shallow breathing pattern causing insufficient ventilation. Hypercapnia is described as an abnormally high

arterial CO2 partial pressure (PaCO2 > 45 mmHg). An elevated PaCO2 is commonly associated with muscle weakness and a reduced exercise capacity in both healthy individuals and individuals with various pathological states. (Burtin et al., 2011; Dreher and Kabitz, 2012; Young, Wilson, Kotsimbos, & Nauthton, 2008; Hackett et al., 1985; Stager, Cordain, Malley, & Sockler, 1985). Furthermore, according to animal studies, it is likely that the functioning of the diaphragm is susceptible to higher PaCO2 levels, resulting in force loss due to diminished contractility of the muscle fibres (Fitzgerald, Hauer, Bierkamper, & Raff, 1984; Jaber et al., 2008; Schnader, Howell, Fitzgerald, & Roussos, 1988). In studies concerning human diaphragms the findings are less consistent and the exact mechanism remains unclear (Hodges & Gandevia, 2000). In contrast to the previously described hypercapnia, hypocapnia can be caused by an altered breathing pattern as well. This breathing pattern occurs when someone is in a state of hyperventilation, which causes a sudden decrease in PaCO2 values. Hyperventilation can have various causes. A study of Sikter, Frecska, Braun, Ghonda and Rhimer (2007) states for example that in patients with panic disorders, hyperventilation was triggered by an increase of PaCO2 levels due to irregular breathing. This state of hypercapnia causes metabolic acidosis, which elicits compensatory hyperventilation to restore PaCO2 values. However, patients with panic disorders overcompensate for this hypercapnia, resulting in a state of hypocapnia. Thereby, a chronic state of hyperventilation can influence the recuperation after a period of voluntary hyperventilation. Hardonk and Beumer (1979) showed that when patients with chronic hyperventilation resumed spontaneous breathing after this period of voluntary hyperventilation, their ventilation decreased less rapidly to baseline levels compared to healthy subjects.

Besides that, there is also an influence of breathing patterns on motor components. During breathing, certain muscles that are also involved in maintaining an upright standing posture are needed, such as the diaphragm. Because of this, our breathing pattern might have an impact on our postural control system. It has been demonstrated that quiet breathing in a standing position perturbs postural control in sagittal and frontal planes due to the deeper and faster rib cage movements (Gurfinkel & Sikh, 1973; Bouisset & Duchene, 1994; Hodges, Gurfinkel, Brumagne, Smith, & Cordo, 2002; Caron, Fontanari, Cremieux, & Joulia, 2004). Furthermore, research indicates that during voluntary hyperventilation, the body sway and compensatory actions increase (Sakellari & Bronstein, 1997). As described previously, a study

of David et al. (2012) showed that postural stability was reduced during a phase of hyperventilation. However, more perturbations were observed during voluntary hyperventilation in comparison with metabolic induced hyperventilation. They state that it is likely that this dissimilarity is caused by a difference in breathing pattern. While they observe an increase in both breathing frequency and tidal volume during voluntary hyperventilation, metabolic induced hyperventilation caused only an increase in rib cage motion amplitude and no change in breathing frequency. Therefore, due to the overlap in function of respiratory muscles and postural control, it might be assumed that there is a possible link between breathing patterns during and after hyperventilation and postural control.

Furthermore, multiple studies show a bidirectional relationship between psychological factors and induced stress on one hand and breathing patterns on the other hand. The feelings a person experiences, both negative and positive, can be expressed through their breathing due to its impact on activity of the autonomic nervous system. Changes in rhythm, depth, location or regularity can occur. For example, feelings of fear as well as anxiety can cause an increase in respiratory activity, expressed by faster and shallower breathing. (Gilbert, 1998; Kreibig, 2010). Also chronic pain causes an altered breathing pattern, more specifically chronic hyperventilation (Glynn, Lloyd, & Folkhard, 1981). Additionally, a study of Jerath, Crawford, Barnes and Harden (2015) stated that breathing is a way to modulate the autonomic nervous system, at which a sympathetic dominant state caused by stress or anxiety can be shifted into a parasympathetic dominant state. This declares the evidence stating that training diaphragmatic breathing is beneficial for reducing stress and therefore also the negative consequences of stress on healthy individuals (Hamasaki, 2020). Considering the previously mentioned effect of breathing pattern on postural control, it can be stated that psychological factors have an indirect effect on postural control.

Next to this indirect effect of psychological factors on postural control, also a direct effect of psychological factors in postural control can be found in literature. In a study of Champagne, Prince, Bouffard and Lafond (2012) a correlation was found between fear of movement and fear avoidance on postural control in patients with low back pain. Similar results were found in an meta-analysis of Christe et al. (2021), they concluded that both higher levels of pain-related fear, catastrophizing and depression were associated with large activity of trunk muscles and reduced amplitudes of spinal movement.

Given the lack of evidence on the relationship between postural control, CO2 levels and psychological factors, the aim of this master thesis is to investigate the influence of induced emotions by means of script-driven imagery, induced hyperventilation by means of a voluntary hyperventilation provocation test and psychological state and trait on center of pressure parameters (COP), trunk muscle activity (EMG) and CO2 values (PetCO2) during postural control in healthy subjects. Therefore, we aimed to answer the following research questions: (1) 'To what extend and in which manner are center of pressure parameters influenced by imagery-induced emotions and hyperventilation condition?' (2) 'To what extend and in which manner is trunk muscle activity influenced by imagery-induced emotions and hyperventilation condition?' (3) 'To what extend and in which manner are PetCO2 levels influenced by imagery-induced emotions and hyperventilation condition?' (4) 'To what extent and in which manner is psychological trait correlated with the response of center of pressure, trunk muscle activity and CO2 values on imagery-induced emotions, hyperventilation condition and hyperventilation provocation?'. Concerning the first three research questions, we postulate that induced emotions of stress will cause an increase in postural sway and trunk muscle activity due to the interference of stress on the functioning of the diaphragm. In addition, we expect the PetCO2 values to decrease. Regarding hyperventilation, we assume that induced voluntary hyperventilation will lead to an increase in postural sway and trunk muscle activity and a decrease in PetCO2 values due to the compromised dual functioning of the diaphragm. Concerning the last research question, we expect that psychological trait will be correlated with center of pressure, trunk muscle activity and CO2 levels, due to the known correlation between psychological factors, postural control and respiration.

3. Methods

3.1. Study design

A cross-sectional design was used to execute this study.

3.2. Subjects

Between March and September 2020, twenty-one healthy subjects participated in this study. They were recruited by social media and personal outreach. Potential subjects received an e-mail to inform them about the protocol and purpose of the study. Thereafter, the following exclusion criteria were screened: respiratory diseases (e.g. chronic obstructive pulmonary disease, interstitial lung disease, pulmonary vascular disease), asthma (except for exertional asthma); neuromuscular diseases (e.g. multiple sclerosis, amyotrophic lateral sclerosis, cardiovascular accident, disease interfering with normal lower limb and trunk function); acute cardiovascular or gastrointestinal disease (e.g. recent acute myocardial infarction, recent coronary artery bypass grafting or percutaneous coronary intervention, heart failure, sickle cell disease, intracranial haemorrhage); diseases which may lead to metabolic hypocapnia (e.g. short bowl syndrome, enteric fistula's, severe diarrhoea, diabetic keto-acidosis); acute pain; secondary chronic pain (e.g. chronic cancer related pain, chronic postsurgical or posttraumatic pain, chronic musculoskeletal pain from persistent inflammation, associated with structural changes, due to disease of the nervous system, chronic neuropathic pain); pregnant and lactating women; major psychiatric conditions (e.g. drugs related disorders, psychotic disorders); acute lower limb problems (e.g. recent anterior cruciate ligament rupture, recent ankle distortion); vestibular disorders and balance problems; vasovagal syncope as a result of prolonged standing; BMI > 30; insufficient knowledge of Dutch language; previous spinal surgery; Dagelijks Leven Klachten Lijst (DLKL) scores >75; Positive And Negative Effect Schedule (PANAS) negative affect score >21 (Watson, Clark, & Tellegen, 1988; Engelen, De Peuter, Victoir, Van Diest, & Van den Bergh, 2006). Informed consent was signed by all participants and the study was approved by the local medical ethics committee (ZOL: B371201941765 and Clinicaltrials.gov: NCT04074798). Demographic features of the 21 included participants can be found in Table 1.

Table 1
Patient characteristics

PATIENT CHARACTERISTICS		
SEX (F/M)	11/10	
NECK PAIN (YES/NO)*	2/12	
WORK STATUS (WORKING/STUDENT)*	4/10	
SMOKING (NEVER/FORMERLY/YES)*	14/0/0	
	M/MED	**SD/IQR**
AGE**	22	4
WEIGHT (KG)	67.90	11.77
HEIGHT (CM)	176.70	9.13
BMI (KG/M²)	21.82	2.49
PANAS NEG*	16.14	3.13
DLKL*	65.57	11.00

**these factors are only acquired in a subgroup of 14 out of 21 participants, ** outcomes are reported in median and inter quartile range due to no normal distribution of data, M = Mean, Med = Median, SD = Standard Deviation, IQR = Inter Quartal Range, m/f = male/female, kg = kilogram, cm = centimeters, BMI = Body Mass Index, PANAS = Positive and Negative Affect Scale, DLKL = Dagelijkse Leven Klachten Lijst*

3.3. Procedure

To provide an answer to the research questions, the following procedure was used:

(1) preparatory phase:
fill in questionnaires and practical preparation

(2) script-driven imagery to induce emotions – pre-hyperventilation:
exposure to four imagery scripts which were imagined as vividly as possible

(3) voluntary hyperventilation provocation phase:
ten-minute baseline measure followed by a voluntary hyperventilation and a five-minute recovery measure

(4) script-driven imagery to induce emotions – post-hyperventilation:
exposure to three imagery scripts which were imagined as vividly as possible

3.3.1. Phase 1: Preparatory phase

The aim of 'Phase 1' was to prepare the participants for the test and to obtain insight in the psychological trait of the participant, so the influence of psychological factors on COP, EMG and PetCO2 could be investigated.

To start, all the participants had to sign an informed consent followed by answering a series of questionnaires including the International Physical Activity Questionnaire short form

(IPAQ), Nijmeegse Questionnaire (NQ), Dagelijks Leven Klachten Lijst (DLKL), 12-item Short form Health Survey (SF-12), Tampa Scale of Kinesiophobia (TSK-11), Need for Controllability and Predictability Questionnaire (NCP-Q), Positive And Negative Affect Schedule (PANAS), Pain Solutions Questionnaire (PaSol), Toronto Alexithymia Scale (TAS-20), Interoceptive Awareness Questionnaire (IAQ), Multidimensional Perfectionism Scale (MPS) and Vragenlijst Belastende Ervaringen (VBE). Participants were instructed to fill in these questionnaires according to their activities and feelings from the past few weeks to obtain the psychological trait of the individuals.

After that, the practical preparation began. A line was drawn in the middle of the participants feet length. They were asked to stand on a transparent sheet with their calcaneus 10 cm apart and forefeet in a freely chosen position. Their footprint was drawn on the sheet and the sheet was placed on the force plate to ensure standardisation between different trials. Subsequently, EMG electrodes were placed on the right body side of the participants according to the SENIAM guidelines. An overview of muscles and EMG electrode placement can be found in Appendix 1. A testing trial was performed to make sure the EMG electrodes were correctly positioned and transmitted an optimal signal. Ultimately, to obtain PetCO2-values, a cannula was placed into the nose of the participants.

3.3.2. Phase 2: Script-driven imagery to induce emotions – pre-hyperventilation

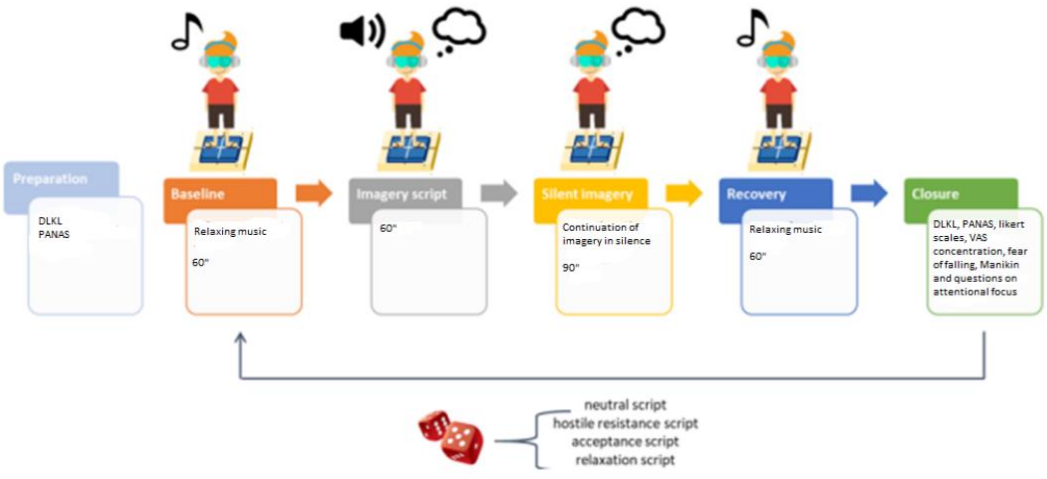
The aim of 'Phase 2' was to measure the influence of induced emotions through script-driven imagery on COP, EMG and PetCO2 during upright standing. Script-driven imagery is a commonly used and valid way to elicit emotions in psychological and neuroscientific research (Holmes & Mathews, 2005; Frewen et al. 2012). The scripts used in this protocol, are adapted versions of those in a study on chronic fatigue syndrome of Bogaerts et al. (2007).

During this phase, participants had to listen to four different imagery scripts of one minute by use of a headphone. Each script was ought to provoke a different emotional status, being; neutral (N), relaxation (R), acceptance (A) and hostile resistance (HR). For acceptance and hostile resistance two versions of the scripts were used, counterbalanced across 'Phase 2' and 'Phase 4'. The content of these scripts can be found in Appendix 2. Every participant started with the neutral script, which was used as a familiarisation trial. These data were not taken into account in data analysis. The following three scripts were presented in a randomized order determined by two researchers. Imagery trials were set up according to the scheme

presented in Figure 1. To start, participants had to fill in the DLKL and PANAS according to the feeling they experienced at that moment, to obtain the psychological state of the subject. This is in contrast with those filled in 'Phase 1', which obtained information about the psychological trait. Then, participants received instructions and information about the procedure of this phase and what was expected. They were told to imagine the situation as vividly as possible and to keep breathing through their nose to ensure continuous PetCO2 monitoring. Specific instructions are listed in Appendix 3. Subsequently, the subjects were positioned in upright standing on the sheet with standardized feet position on a foam pad (Airex Balance pad Elite, 50x41x6 cm), the headphone was put on, lights were dimed and the measure of CO2, COP and EMG started simultaneously. First, relaxing music was played for 60 seconds (Sarabande, Goldberg Suite, E. Grieg), followed by playing the auditory imagery script with a duration of 60 seconds. Hereafter, there was a silent period of 90 seconds in which the participants were instructed to keep imaging the end situation of the script as vividly as possible. After 45 seconds an auditory cue was presented, as a reminder to keep imagining the situation. Finally, relaxing music was played once more for 60 seconds, as a recovery period (Gymnope´die no. 1, E. Satie) and participants were instructed to stop the imagery during that period. After every script, subjects had to fill in additional questionnaires to acquire information about their ability to focus on the script, the psychological effect the scripts had on the participants and about their fear of falling. A complete overview of these questionnaires can be found in Appendix 4. This was repeated for each script.

Figure 1

Set up imagery trails



3.3.3. Phase 3: Hyperventilation provocation test

The aim of 'Phase 3' was to induce a voluntary hyperventilation provocation test to remark possible differences in COP, EMG and PetCO2 between 'Phase 2' (pre-hyperventilation) and 'Phase 4' (post-hyperventilation) and additionally obtain the time in which PetCO2 values were restored to their baseline levels per subject.

In this phase, the subjects were asked to sit in a chair in a relaxed position, with feet and arms supported on the ground and thighs respectively. They were seated for ten minutes while breathing through their nose to obtain the baseline PetCO2 values. After ten minutes, the researchers gave a sign and the participant started the voluntary hyperventilation. For this part, subjects had to breathe through their mouth and were asked to increase their breath volume and depth to 60 breaths/minute. The researcher took place in front of the subject, and indicated the breathing rhythm. As soon as the participant felt an alteration in physical sensations, such as tingling lips or fingers, they were asked to raise their hand and to immediately resume their normal breathing through the nose for five more minutes to evaluate the recovery time.

3.3.4. Phase 4: Script-driven imagery to induce emotions – pre-hyperventilation

The aim of 'Phase 4' was to investigate the possible influence of hyperventilation in 'Phase 3' on COP, EMG and PetCO2 during upright standing. This insight is acquired by comparing data of the pre-hyperventilation imagery in 'Phase 2' with the post-hyperventilation imagery of 'Phase 4'.

In this phase, the subjects once more underwent the imagery trails as described in 'Phase 2'. The only differences were that the neutral script was excluded in this phase and the hostile resistance and acceptance script differed from 'Phase 2', as counterbalanced versions were used (see Appendix 2).

3.4. Outcome measurements

3.4.1. Primary outcome measurements

This experimental investigation contained three primary outcomes, being center of pressure (COP), electromyographic activity (EMG) and end tidal carbon dioxide pressure (PetCO2).

3.4.1.1. COP

The first one was center of pressure (COP). The following COP variables were obtained: maximal displacement (COP max), minimal displacement (COP min), standard deviation (COP std), roots mean square (COP rms), mean velocity (COP meanvel), maximal velocity (COP maxvel), sway path (COP swaypath), normal sway (COP normsway) in medio-lateral (ML) and antero-posterior (AP) direction. Additionally, sway path total (COP swaypath tot), sway area total (COP swayarea tot) and normal sway area (COP norm swayarea) were acquired. These parameters were registered through a 6-channel force plate (Advanced Medical Technology Inc. (AMTI), Watertown, USA) that measures the vertical ground reaction forces.

3.4.1.2. EMG

The second primary outcome measure was the muscle activation amplitude of the m. rectus abdominus, m. obliquus internus, m. erector spinae, m. multifidus, m. intercostalis externus, m. sternocleidomastoideus and m. trapezius. Seven bipolar EMG units (Trigno, Delsys inc., Natick, USA) were placed on specific locations of these muscles on the right side of the body (see Appendix 1) to acquire this data.

3.4.1.3. PetCO2

The third primary outcome was the end tidal carbon dioxide pressure (PetCO2), measured by a handheld capnograph (Masimo Rad-97 TM Pulse CO-Oximeter® with NomoLine™ Capnography). All primary outcome measurements were simultaneously acquired in an upright standing position on a foam with eyes closed.

3.4.2. Secondary outcome measurements

Secondary outcome measurements, namely the psychological state and trait, were determined by the use of questionnaires.

3.4.2.1. Psychological trait

To obtain information about the psychological trait, the following questionnaires were used: NQ to measure the perceived hyperventilation, DLKL to collect information about possible complaints in daily live, PANAS to measure affect scores, TSK-11 to measure kinesiophobia, NCP-Q to assess the need for being able to control and predict situations, PaSol to measure acceptance of pain, TAS-20 to measure the alexithymia, IAQ to obtain information about interoceptive awareness, IPAQ to assess amounts of physical activity, SF-12 to measure health related quality of life, MPS to measure other-oriented and socially prescribed perfectionism

and finally, the VBE assessed the specific altered self-perception and aversive childhood experiences.

3.4.2.2. Psychological state

To acquire insight in the psychological state of the participants after every imagery script, a questionnaire bundle was filled in (see Appendix 4). This bundle contained five questions about the attentional focus while imaging (AFQ), six questions about the imagery itself (Likert 1, Likert 2, Likert 3, Manikin 1, Manikin 2, Manikin 3), one question about fear of falling during the imagery (FOF) and eventually the PANAS and the DLKL to obtain information about the physical and emotional complaints provoked by the scripts.

3.5. Data processing and analysis

3.5.1. COP

The software Simi was used to calculate COP displacements by means of forces exerted on the force plate in X, Y & Z axes. COP displacements both in medio-lateral (ML) and anterior-posterior (AP) direction were measured in distance (m) from the center of the force plate. Thereafter COP data were filtered using a 4^{th}- order Butterworth filter with a lowpass cut-off at 6 Hz. COP baseline offset was corrected by subtracting mean COP in either direction from all COP measurements in the corresponding direction.

3.5.2. EMG

EMG data were filtered using a 4^{th}-order Butterworth filter with a high-pass filter at 20 Hz, full-wave rectified, and smoothed using a 100 point moving average filter. First the maximum activation for each muscle was determined during the fast ballistic arm movement up to 90 degrees anteflexion. To this maximal activation the other trials were normalized and expressed in %.

3.5.3. PetCO2

Raw waveform signals for PetCO2 data were uploaded to a personal computer, calibrated and reduced (parameter extraction, trend generation) by the VivoLogic software and exported to spreadsheets. Baseline PetCO2 values were determined by taking the mean value of PetCO2 during 10 minutes baseline measurement of hyperventilation provocation test. During recovery, mean PetCO2 volume was measured in 5 time slots of one minute.

3.6. Statistical analysis

To evaluate the influence of induced emotions and hyperventilation on COP, EMG and PetCO2 values, 3 within-subject factors were used: script (R, A, HR), phase of the script (baseline, imagery, recovery) and condition (before and after hyperventilation provocation test). For analysing the effect of induced emotions through script-driven imagery and hyperventilation on state questionnaire response, only script (R, A, HR) and condition (before and after hyperventilation provocation test) were used as within-subject factors. Additionally, potential interactions between the three within-subject variables were explored.

To start, the assumption of normality was evaluated by means of the normal quantile plot. For non-normally distributed data, log-transformations were performed to see if this transformation resulted in a normal distribution of the data. If this was the case, the assumption of normality was met. In case of normal distributed data, repeated measures ANOVA was used to check if there was a significant effect of the within-subject factors on COP, EMG and PetCO2 values. When a significant effect was found, Tukey's test was used as post hoc analysis. When data were not normally distributed, Wilcoxon/Kruskal-Wallis test was used to identify significant interaction.

Additionally, correlation statistics were used to investigate correlations between trait questionnaires (NQ, TAS-20, MPS) and primary outcome measures on one hand and trait questionnaires (NQ, TAS-20, MPS) and recovery time after the hyperventilation provocation test on the other hand. Non-parametric test Spearman rho correlations were used due to small sample size ($n<30$).

4. Results

4.1. Demographic characteristics

In total, 21 participants were included in this study. All participants underwent the whole testing procedure. The PetCO2 data of one subject was missing, due to technical difficulties. The mean age of the participants was 22 (+-4), 52,41% of the participants is female and the mean BMI is 21,82 (+-2,49). In Table 1, a summarisation of demographic data can be found.

4.2. Center of pressure (COP)

Results of COP measurements can be found in Appendix 5. The effect of (1) the phase of each script (baseline – imagery – recovery), (2) the script itself (R – A – HR) and (3) the condition of the imagery script (prehyp – posthyp) on COP are described in the following paragraphs.

4.2.1. Effect of imagery on COP

A significant main effect of phase (baseline – imagery – recovery) was found on all COP variables except for the maximal velocity in anteroposterior (AP) direction and minimal displacement in mediolateral (ML) direction. P- and F-values are listed in Table 2.

Tukey's test indicated that for COP max (AP: $P < 0.05$, ML: $P < 0.05$), COP maxvel (ML: $P < 0.05$), COP meanvel (AP: $P < 0.05$, ML: $P < 0.05$), COP normsway (AP: $P < 0.05$, ML: $P < 0.05$), COP std (ML: $P < 0.05$), COP swaypath (AP: $P < 0.05$, ML: $P < 0.05$, total: $P < 0.05$) and swayarea ($P < 0.05$) a significant difference was found between the baseline and imagery phase of the script. More specifically, the COP values increased significantly while imaging compared to the baseline values for COP max, COP maxvel, COP std, COP swaypath, and COP swayarea. The opposite occurred regarding COP meanvel and COP normsway.

Additionally, a significant difference between the imagery and recovery phase was found regarding COP swaypath (AP: $P < 0.05$, ML: $P < 0.05$, total: $P < 0.05$), COP rms (AP: $P < 0.05$, ML: $P < 0.05$), COP normsway (ML: $P < 0.05$), COP meanvel (ML: $P < 0.05$) and COP min (ML: $P < 0.05$). More specifically, COP swaypath significantly decreased in the recovery phase compared to the imagery phase. This is in contrast to COP rms, COP normsway, COP meanvel and COP min which increased in the recovery phase compared to the imagery phase.

Lastly, for COP max (ML: $P < 0.05$), COP std (AP: $P < 0.05$, ML: $P < 0.05$), COP swaypath (ML: $P < 0.05$, total: $P < 0.05$) and swayarea ($P < 0.05$) significant differences between the baseline

and recovery phase of the imagery trail were found. Further analyses showed that the COP values were significantly higher in the recovery phase, compared to the baseline phase for COP max, COP std and COP swayarea. The opposite occurred for COP swaypath.

4.2.2. Effect of different emotion-induced scripts on COP

Effects of script (R – A – HR) were only found on the minimal COP displacement in ML direction and the total sway path. P- and F-values can be found in Table 2. Tukey's test showed that for both COP variables there was a significant difference between the R and HR script ($P < 0.05$). More specifically, COP min values were higher during the HR script compared to the R script, and total sway path values were higher during the R script compared with the HR script. Furthermore, an effect of total sway path was also found between the A and R script ($P < 0.05$). More specifically, COP values were significantly higher during the R script compared to the A script.

4.2.3. Effect of condition (pre-post hyperventilation) on COP

For condition (prehyp – posthyp), a significant main effect was only found for the maximal velocity of COP displacements in ML direction ($F = 10.38$, $P = 0.004$). More specifically, COP values were significantly lower ($P < 0.05$) in the post-hyperventilation phase compared to the pre-hyperventilation phase. F- and P-values can be found in Table 2.

4.2.4. Interaction effect of phase – script – condition on COP

Several significant interaction effects were observed between phase, script and condition. To start, a significant interaction effect of script and phase was found on COP std (AP: $F = 2.56$, $P = 0.045$) and sway path (total: $F = 7.18$, $P < 0.001$). Additionally, significant interaction effects were observed between condition and phase for COP rms (ML: $F = 3.47$, $P = 0.041$), COP std (ML: $F = 4.13$, $P = 0.023$) and sway area ($F = 3.64$, $P = 0.035$). Furthermore, between condition and script as well as between condition, script and phase, significant interactions were observed in sway path total, respectively ($F = 28.15$, $P < 0.001$) and ($F = 16.86$, $P < 0.001$).

Table 2
Effect of phase, scrip and condition on COP

PHASE	**AP**		**ML**	
	P-value	**F-value**	**P-value**	**F-value**
COPmax	**0.001**	8.30	**< 0.001**	15.85
COPmaxvel	0.205	1.65	**0.002**	7.24
COPmeanvel	**0.030**	3.83	**0.017**	4.54
COPmin	**0.031**	3.78	0.071	2.82
COPnormsway	**0.030**	3.83	**0.017**	4.54
COPrms	**0.007**	5.58	**0.002**	7.04
COPstd	**0.022**	4.205	**0.003**	6.96
COPswaypath	**< 0.001**	121.19	**< 0.001**	242.09
	P-value		**F-value**	
COPswaypath total	**< 0.001**		178.95	
Sway area	**0.004**		6.53	

SCRIPT	**AP**		**ML**	
	P-value	**F-value**	**P-value**	**F-value**
COPmax	0.803	0.22	0.179	1.80
COPmaxvel	0.814	0.21	0.588	0.54
COPmeanvel	0.793	0.23	0.747	0.29
COPmin	0.736	0.31	**0.023**	4.16
COPnorm sway	0.793	0.23	0.747	0.29
COPrms	0.667	0.41	0.217	1.59
COPstd	0.728	0.32	0.092	2.53
COPsway path	0.829	0.19	0.762	0.27
	P-value		**F-value**	
COPsway path total	**< 0.001**		14.31	
Sway area	0.174		1.83	

CONDITION	**AP**		**ML**	
	P-value	**F-value**	**P-value**	**F-value**
COPmax	0.147	2.27	0.103	2.93
COPmaxvel	0.991	0.01	**0.004**	10.38
COPmeanvel	0.755	0.10	0.324	1.02
COPmin	0.561	0.35	0.797	0.07
COPnorm sway	0.755	0.10	1.02	0.324
COPrms	0.214	1.65	0.189	1.85
COPstd	0.103	2.92	0.192	1.82

COPsway path	0.103	2.92	0.667	0.19
	P-value		**F-value**	
COPsway path total	0.915		0.02	
Sway area	0.247		1.42	

*< **0.05** / > 0.05; COP = center of pressure, AP = anterior-posterior, ML = medial-lateraal, max = maximal activity, maxvel = maximal velocity, meanvel = mean velocity, min = minimal activity, normsway = time-normalized sway path, rms = root mean square, std = standard deviation, swaypath = total sway path*

4.3. Trunk muscle activity (EMG)

Results of EMG measurements can be found in Appendix 6. The effect of (1) the phase of each script (baseline – imagery – recovery), (2) the script itself (R – A – HR) and (3) the condition of the imagery script (prehyperventilation – posthyperventilation) on EMG amplitude are described in the following paragraphs.

4.3.1. Effect of imagery on EMG

No significant effect of the phase of the script on mean EMG values was found (P > 0.05).

4.3.2. Effect of different emotion-induced scripts on EMG

No significant effect of the script on mean EMG values was found (P > 0.05).

4.3.3. Effect of condition (pre-post hyperventilation) on EMG

There was a significant main effect of condition on mean EMG values of the m. erector spinae (F = 7.98, P = 0.011). More specifically, EMG values were significantly higher during the pre-hyperventilation phase compared to the post-hyperventilation phase (P < 0.05).

4.3.4. Interaction effect of phase – script – condition on EMG

Interaction effects were found between condition and phase for the mean EMG values of the m. rectus abdominis (F = 6.61, P = 0.003), the m. trapezius (F = 5.41, P = 0.008). Additionally, an interaction effect was found of condition, script and phase on EMG values of m. erector spinae (F = 2.78, P = 0.032) and m. sternocleidomastoideus muscle (F = 2.76, P = 0.033).

4.4. CO2 levels (PetCO2)

Results of PetCO2 measurements can be found in Appendix 7. The effect of (1) the phase of each script (baseline – imagery – recovery), (2) the script itself (R – A – HR) and (3) the condition of the imagery (prehyperventilation – posthyperventilation) on PetCO2 are described in the following paragraphs. Additionally, the effect of the hyperventilation provocation test is elucidated.

4.4.1. Effect of imagery on PetCO2

There were no significant main effects of phase on mean PetCO2 values ($P > 0.05$).

4.4.2. Effect of different emotion induced scripts on PetCO2

There were no significant main effects of script on mean PetCO2 values ($P > 0.05$).

4.4.3. Effect of condition (pre-post hyperventilation) on PetCO2

A significant main effect of PetCO2 was found on condition ($F = 4.83$, $P = 0.041$). During the pre-hyperventilation phase PetCO2 values were higher in comparison to the post-hyperventilation phase ($P < 0.05$).

4.4.4. Interaction effect of phase – script – condition on PetCO2

A significant interaction effect was observed of script and phase on PetCO2 ($F = 2.75$, $P = 0.034$). When performing Tukey's test, no significant differences were found.

4.5. State questionnaires: obtained during experiment

The effect of (1) the script itself (R – A – HR) and (2) the condition of the imagery (prehyp – post) on questionnaire responses are described in the following paragraphs. The scores of the questionnaires can be found in Appendix 8.

4.5.1. Effect of different emotion-induced scripts on questionnaire responses (state)

A significant main effect of script (R – A – HR) was found on all variables except for Likert 3 and FOF questionnaire (Likert 1: $F = 3.57$, $P = 0.037$; Likert 2: $F = 6.42$, $P = 0.004$; DLKL: $F = 5.41$, $P = 0.008$; PANAS total: $F = 6.60$, $P = 0.003$; PANAS positive: $F = 18.46$, $P < 0.001$; PANAS negative: $F = 8.75$, $P = 0.001$; MANIKIN 1: $F = 52.46$, $P < 0.001$; MANIKIN 2: $F = 20.12$, $P < 0.001$; MANIKIN 3: $F = 16.07$, $P < 0.001$).

Tukey's test showed that for DLKL ($P < 0.05$), PANAS total ($P < 0.05$), PANAS positive ($P < 0.05$), PANAS negative ($P < 0.05$), MANIKIN 1 ($P < 0.05$), MANIKIN 2 ($P < 0.05$) and MANIKIN 3 ($P < 0.05$) the significant difference was found between the A and HR script. Further analysis showed that the scoring of MANIKIN 3, MANIKIN 2, PANAS positive and PANAS total was significantly higher after the acceptance script than after the hostile resistance script. This indicates that more feelings of control and tranquillity and less feelings of physical and emotional stress were provoked. The opposite occurred in the scoring of the DLKL, PANAS

negative and MANIKIN 1. These findings indicate that the hostile resistance script provoked more emotional and physical distress than the acceptance script.

Moreover, a significant difference between the R and HR script was found for Likert 1 ($P < 0.05$) Likert 2 ($P < 0.05$), DLKL ($P < 0.05$), PANAS positive ($P < 0.05$), PANAS negative ($P < 0.05$), MANIKIN 1 ($P < 0.05$), MANIKIN 2 ($P < 0.05$) and MANIKIN 3 ($P < 0.05$). More specifically, the Likert 1, Likert 2, DLKL, PANAS negative and MANIKIN 1 scored significantly higher after imagery of the hostile resistance script compared to the relaxation script. This suggests that it was harder to emphasise, it was a more unpleasant imagery and physical and emotional stress were provoked during the hostile resistance script. In contrary, the PANAS positive, MANIKIN 2 and MANIKIN 3 reached significantly lower scores after the hostile resistance script compared with the relaxation script. These findings suggest that the hostile resistance script induced more emotional and physical distress than the relaxation script.

Finally, only for the PANAS total ($P < 0.05$), MANIKIN 1 ($P < 0.05$) and MANIKIN 2 ($P < 0.05$) a significant difference was found between the A and R script. PANAS total and MANIKIN 1 reached higher scores after imagery of the acceptance script than after imagery of the relaxation script, in contrast to MANIKIN 2 that reached the highest scores after imagery of the relaxation script. This indicates that the subjects perceived a more pleasant and calm feeling after imagery of the relaxation script compared to the acceptance script.

4.5.2. Effect of condition (pre-post hyperventilation) on questionnaire responses

No significant effect was found of the condition (prehyp – posthyp) on the questionnaire responses ($P > 0.05$).

4.5.3. Interaction effect of script – condition on questionnaire responses

No significant interaction effects between script (R – A – HR) and condition (prehyp – posthyp) were found ($P > 0.05$).

4.6. Trait questionnaires: obtained before experiment

4.6.1 Baseline scores

In Table 3, the mean scores of the trait questionnaires are presented. According to the trait questionnaire bundles, 57,15% of the participants appeared to be highly active. The mean score of the Toronto Alexethymia Scale (TAS-20) is situated above the cut-off score, which indicates a possible existence of alexithymia. The mean scores of the other questionnaires all

fell within the normal range. Afterwards, individual scores were analysed as well. These analysis demonstrated that two subjects scored above the cut-off score on the Nijmegen Questionnaire (NQ), indicating that two participants had possible symptoms of hyperventilation. Also, one subject scored above the cut-off score on the Tampa Scale of Kinesiophobia (TSK-11), indicating fear of movement in one subject and twelve did for the TAS-20, suggesting the presence of alexithymia.

Table *3*
Baseline questionnaires scores (trait)

QUESTIONNARES	SCORES	
IPAQ	12 highly active – 6 moderately active – 3 slightly active	
	M	**SD**
NQ	9.48	5.95
DLKL	62.47	12.45
SF-12 PHYSICAL	54.71	4.37
SF-12 MENTAL	53.00	4.54
TSK-11	28.29	6.54
NCP-Q	43.67	11.49
PANAS TOTAL	49.38	5.44
PANAS POS	34.48	6.12
PANAS NEG	14.90	3.45
PSQ	54.67	9.51
TAS-20	54.24	5.86
IAQ TOTAL	55.29	7.70
IAQ NEUTRAL	27.95	4.92
IAQ UNPLEASANT	27.33	4.19
MPS	80.00	11.92
VBE	0.00	0.00

M = mean, SD = standard deviation, IPAQ = International Physical Activity Questionnaire, NQ = Nijmegem Questionnaire , DLKL = Dagelijkse Leven Klachten Lijst , SF-12 PHYSICAL = 12-item Short Form Health Survey – physical subscale, SF-12 MENTAL = 12-item Short Form Health Survey - mental subscale, TSK-11 = Tampa Scale for Kinesiophobia, NCP-Q = Need for Controllability and Predictability Questionnaire, PANAS TOTAL = Positive and Negative Affect Scale - total, PANAS POS = Positive and Negative Affect Scale – positive subscale, PANAS NEG = Positive and Negative Affect Scale – negative subscale, PSQ = Pain Solutions Questionnaire, TAS-20 = Toronto Alexithymia Scale, IAQ TOTAL = Interoceptive Awareness Questionnaire – total, IAQ NEUTRAL = Interoceptive Awareness Questionnaire – neutral subscale, IAQ UNPLEASANT = Interoceptive Awareness Questionnaire – unpleasant subscale, MPS = Multidimensional Perfectionism Scale, VBE = Vragenlijst Belastende Ervaringen

4.6.2. Correlations between trait questionnaires and CO2, EMG and COP

The Nijmegem Questionnaire (NQ), Toronto Alexythemia Scale (TAS-20) and the Multidimensional Perfectionism Scale (MPS) were further analysed to study possible correlations on primary outcome measures. Those specific questionnaires were selected due to the fact that some participants scored above the cut off scores of the NQ and TAS, and

recent research indicated a possible correlation between PetCO2 and MPS (Ramakers et al. 2021).

Spearman Rho showed a significant correlation between the TAS-20 and the NQ (Spearman ρ = 0.463, P = 0.034) and between the mean PetCO2 values of 'Phase 3' and the MPS (Spearman ρ = -0.544, P = 0.013). Further exploration indicated that higher scores of the TAS-20 were correlated with higher scores on the NQ and additionally, higher scores on MPS were correlated with lower PetCO2 values.

Concerning the EMG activity and COP values, no significant correlations were found with the previously mentioned questionnaires (P > 0.05).

4.6.3. Attentional focus questionnaires

Concerning the attentional focus questionnaires (AFQ), many interindividual differences were found. Mean AFQ scores ranged from zero to four. A more detailed analysis per phase is listed in Appendix 9.

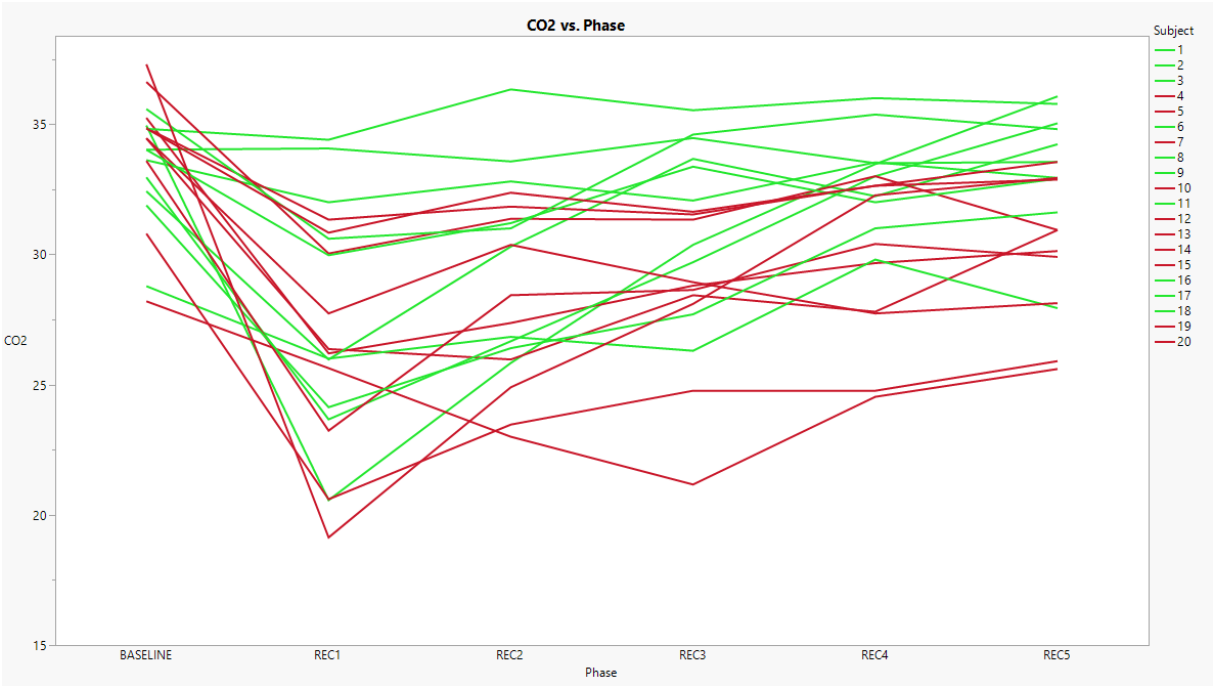
4.7. Hyperventilation provocation

4.7.1. Mean CO2 values

At the 10-minute baseline period, the mean PetCO2 value of all subjects was 33.7 (+- 2.3). During the 5-minute recovery period, the mean values were at its lowest in the first minute of recovery, and inclined gradually. The mean PetCO2 values were respectively 27.1 (+- 4.5), 29.0 (+- 3.6), 30.0 (+- 3.6), 31.3 (+- 3.1) and 31.8 (+- 3.1) for minute 1 – 2 – 3 – 4 – 5 of the recovery period.

However, many interindividual differences were observed during the recovery period. After more detailed analysis, it appeared that only half of the participants returned to their baseline PetCO2 levels within ten minutes after stopping hyperventilation. More details are listed in Figure 2. In Appendix 10 baseline PetCO2 levels, minimal PetCO2 levels and recovery time are shown.

Figure 2
Mean PetCO2 values of all participants separately



REC1 = recovery phase minute 1, REC2 = recovery phase minute 2, REC3 = recovery phase minute 3, REC4 = recovery phase minute 4, REC5 = recovery phase minute 5

4.7.2. Correlations between questionnaires and recovery time of hyperventilation

No significant correlations were found between the NQ, MPS, TAS and the recovery time after the hyperventilation provocation test, more information is demonstrated in Table 4.

Table 4
Correlation analysis of recovery time and NQ, TAS-20 and MPS

	RECOVERY TIME	
	Spearman ρ	**P-value**
NQ	-0.1883	0.427
TAS-20	0.0361	0.880
MPS	-0.3214	0.167

NQ = Nijmegem Questionnaire, TAS-20 = Toronto Alexithymia Scale, MPS = Multidimensional Perfectionism Scale

5. Discussion

In the following paragraphs the reflection of our findings, clinical implications, strengths and weaknesses and recommendations for further research will be elucidated.

5.1. Reflection of findings in function of research questions

This research aimed to investigate the influence of induced emotions by means of script-driven imagery, induced hyperventilation by means of a voluntary hyperventilation provocation test and psychological state and trait on center of pressure parameters, trunk muscle activity and end tidal carbon dioxide pressure during postural control in healthy subjects. Our first three research questions focused on the effect of induced hyperventilation and induced emotions on COP, EMG and PetCO2 values. For the effect of hyperventilation, our assumptions were in accordance with the findings of this study, considering the fact that the hyperventilation provocation test influenced the COP, EMG and PetCO2 values. However, considering induced emotions, our hypotheses were not entirely consistent with the findings of this study. The imagery scripts, and in particular the hostile-resistance, had apparent effects on the COP values but not on the EMG activity and PetCO2 values. For the last research question, targeting psychological trait, no correlation was found between these results and COP and EMG, which was not in line with our hypotheses. However, a correlation was found between PetCO2 and the MPS.

5.1.1. Center of pressure (COP)

Emotion inducing imagery, free from the content, during unstable upright standing without vision had an effect on postural control (i.e. changes in COP values). The most remarkable differences in COP values were situated between the baseline and the imagery phase, but it is noteworthy that between all phases significant effects were found. These results indicate that it was harder to maintain postural control during imagery compared with baseline without imagery as COP max, COP maxvel, COP std, COP sway path and COP sway area increased. Only the mean velocity and the COP norm sway decreased while imaging. Nevertheless, it should be noted that the COP variables increasing from baseline to imagery phase, are not the same COP variables that are increasing form imagery to recovery. Thus, it is not the case that postural stability solely decreases throughout the script for all COP variables. No pattern was found in the response of the different COP variables, not when analysing the variables on

itself, neither when subdividing them into categories of amplitude and variability. The COP sway path is the only COP variable that significantly differs between the three phases of the scripts. Earlier research indicates that this variable is a valid outcome measure in numerous populations and balance conditions (Donath, Roth, Zahner, & Faude, 2012). Analysing this COP variable, it is observed that the sway path increased from baseline to imagery phase, and then decreased again through the recovery phase beneath the baseline levels. Therefor an increase in postural sway is not per se induced by auditory stimuli, as a decrease is present during the recovery phase. This is in accordance with a study of Palm, Strobel, Achatz, von Luebken and Friemert (2009), who concluded that auditory signals do not appear to influence postural control. However, participants in this study were instructed to focus on the auditory information they received and emphasise the situation as vividly as possible, which actually prompted them to perform a double task. Considering this, the evidence that cognitive systems might interfere with postural control should be taken into account while interpreting our results (Andersson, Hagman, Talianzadeh, Svedberg, & Larsen, 2002; Fraizer & Mitra, 2008; Huxhold, Li, Schmiedek, & Lindenberger, 2006; Melzer, Benjuya, & Kaplanski, 2001; Pellecchia, 2003). Thereby, the postural control task participants had to perform in this study, standing on a foam, requires a great attentional demand to maintain a stable upright position according to earlier research (Lajoie, Teasdale, Bard, & Fleury, 1993). A study of Yardly et al. (1999) concluded that an additional cognitive load did not increase sway path when healthy young adults were standing on an unstable support surface. However, a review of Woollacott & Shumway-Cook (2002) concluded that postural control in healthy young adults is attentionally demanding, but the effects are rather small and appear in situations where the postural control system is stressed and persons had to perform a complex secondary task. Moreover, the 'capacity sharing theory' should be taken into account. This states that if the attentional requirements of the simultaneous performance of the dual tasks overstep the information processing capacity, the performance of one or both tasks will decrease (Shanbehzadeh, Salavati, Talebian, Khademi-Kalantari, & Tavahomi, 2018). This theory substantiates our findings, considering that the postural stability decreased during the imagery phase compared with the baseline phase and the normalisation of the COP sway path during the relaxation phase.

The emotional content of the imagery scripts, presented at the participants during unstable upright standing without vision, did influence postural control as well (i.e. changes in COP values). COP min values in medial-lateral direction were higher during the hostile resistance script compared with the relaxation script, the opposite occurred for total sway path values. Furthermore, total sway path values were significantly higher during the relaxation script compared to the acceptance script. Due to these inconsistent findings, it is hard to conclude which script evoked the most difficulties in maintaining postural control.

Subjects were submitted to a voluntary hyperventilation provocation test, after which imagery scripts were presented once more. This hyperventilation provocation test had also a significant effect on postural control (i.e. changes in COP values). COP maxvel values in medial-lateral direction were significantly lower in the post-hyperventilation phase compared to the pre-hyperventilation phase, which might suggest participants experienced better postural control in the post-hyperventilation condition. This is not in line with our hypothesis, which stated that there would be more postural sway during the post-hyperventilation condition. However, since this appeared only in one COP-value, results need to be interpreted with some precautions. The fact that voluntary hyperventilation had no effect on other COP values in this study could be declared by the five minute recovery period after voluntary hyperventilation, as other studies investigated these interactions directly after or during hyperventilation (Sakellari, Bronstein, Corna, Hammon, Jones, & Wolsley, 1997; Sakellari & Bronstei, 1997). The above mentioned study showed that voluntary hyperventilation has an effect on postural control only for a period of two to five minutes, which might declare why we did not find an effect on most of our COP variables.

5.1.2. Trunk muscle activity (EMG)

Only condition (pre-post hyperventilation) had a significant effect on trunk muscle activity (i.e. changes in EMG). Activity of the erector spinae was significantly higher during the pre-hyperventilation phase, compared to the post-hyperventilation phase. This might indicate that the erector spinae had to work harder to maintain postural control in the pre-hyperventilation phase, which is in accordance with the higher COP values in this phase. Another possible declaration for this finding, is that the erector spinae might have been enabled as auxiliary respiratory muscle which led to fatigue after the hyperventilation.

5.1.3. CO2 levels (PetCO2)

PetCO2 values were only significantly affected by condition (pre-post hyperventilation). PetCO2 values were lower in the post-hyperventilation phase in comparison to the pre-hyperventilation phase. This might be due to the fact that PetCO2 levels did not return to baseline levels yet after the hyperventilation provocation test. More specifically, only half of the participants returned to their baseline PetCO2 levels after the recovery phase. This might be a declaring factor for the significantly higher PetCO2 values before the hyperventilation provocation test, as described above. This is in accordance with earlier research, as Achenbach, Siao, Mavroudakis, Chiappa and Kiers (1994) stated that PetCO2 returned to baseline 8-10 minutes after induced hyperventilation. However, in this study hyperventilation was attained for three minutes which is a remarkably longer duration of hyperventilation compared to our study. Thus, on one hand recuperation time might have been too short, considering that the PetCO2 levels did not return to baseline yet. On the other hand however, as described earlier, recuperation time might have been too long as the hyperventilation-provocation test affects the COP values for a period of two to five minutes. The fact that no significant effect of script on PetCO2 was found, is in contrast with earlier research. Bogaerts et al. (2007) reported a significant effect of script on PetCO2 values. A possible declaration for this inconsistency might be that the participants of our study were healthy individuals. As indicated by earlier research, hyperventilation could be an epiphenomenon of the chronic fatigue syndrome (Bazelmans, Bleijenberg, Vercoulen, van der Meer, & Folgering, 1997; Riley, O'Brien, McCluskey, Bell, & Nicholls, 1990; Saisch, Deale, Gardner, & Wessely, 1994; Tweeddale, Rowbottom, & McHardy, 1994), which might declare the fact that Bogaerts et al. (2007) found a significant effects of scripts on PetCO2, that did not arise in this study. Another difference is the fact that the subjects in the experiment of Bogaerts et al. (2007) were tested in a seating position instead of a standing position. A study of Lajoie, Teasdale, Bard, LaRue and Fleury (1993) concluded that maintaining an upright standing position requires more attention compared to a sitting position. Regarding the 'capacity sharing theory' described earlier, it could be harder for participants in this study to perform the dual task. Therefore, the imagination could be more vividly in participants who were positioned in a sitting position compared to a standing position leading to an effect of script on PetCO2 levels.

5.1.4. State questionnaires: obtained during experiment

Only the emotional content of the imagery scripts, presented at the participants during unstable upright standing without vision did influence questionnaires responses. This research indicates that the hostile-resistance script provoked more emotional and physical distress than the acceptance and the relaxation script. Additionally, the subjects perceived a more pleasant and calm feeling after imagination of the relaxation script compared to the acceptance script. These findings affirm that the emotion driven scripts used in our study evoked the previously defined emotions. This is consistent with earlier research of Bogaerts et al. (2007), who stated that more symptoms were reported during hostile resistance scripts compared with the relaxation scripts in patients with chronic fatigue syndrome. Nevertheless, all participants had to listen to the same scripts validated for low back pain patients. Therefore it could be harder for healthy participants to relate to these situations, which may influence the outcomes. When looking at the Likert scales measuring to what extent participants could emphasize the situation, results are significantly higher after imagery of the hostile resistance script compared with the relaxation script. This suggests that is was harder to emphasise with the hostile resistance script.

5.1.5. Trait questionnaires: obtained before experiment

Before the start of the testings, participants had to fill in several questionnaires to determine their psychological trait. Only 3 of the 21 participants reported to be slightly active according to the IPAQ. A study of Kuh, Bassey, Butterworth, Hardy and Wadsworth (2005) demonstrated that balance performance was better in participants who were moderately active compared to inactive participants. This may lead to biased results considering the fact that more physical activity leads to better functioning of the different controlling systems for postural control. In subsequent studies a correlation between physical activity level and postural control measurements should be explored to rule out this bias, or physical activity should be considered a confounding variable. Additionally, the mean score of the TAS-20 were above the cut-off score, indicating a possible influence of alexithymia. This might have had an influence on the results of this study, due to the inability of participants to process and describe their feelings during listening to the script (Martinez-Sanchez, Ato-Garcia, & Ortiz-Soria, 2003). Results of correlation analyses did not show any correlation between the rate of alexithymia and primary outcome measures COP, EMG and PetCO2, nevertheless a correlation

with NQ score was present. This could be declared by the fact that this limited emotional awareness can lead to prolonged and amplified physiological arousals (Martinez-Sanchez, Ato-Garcia & Ortiz-Soria, 2003). Another psychological trait investigated in this study is the level of perfectionism by means of the MPS. Maladaptive perfectionism is related to dysfunctional breathing patterns, which in turn will influence PetCO2 values (Ramakers et al., 2021). This is in line with findings in this study suggesting a negative correlation between MPS score and PetCO2 values. Regarding the attentional focus questionnaires, it appeared difficult to stay focused on the scripts. This is important to keep in mind as this might have led to less accurate results. Nevertheless, from a methodological point of view, significant effects of scripts on state questionnaires were found which indicates that the scripts did provoke emotions.

5.2. Clinical implications

The findings of this explorative study provide us with a broader insight into the relation between hyperventilation, induced emotions, postural control, CO2 levels and psychological factors. Considering the high prevalence of psychological factors (e.g fear of movement) in patients with musculoskeletal disorders affecting postural control, for example low back pain, this is an important aspect. Particularly due to the fact that psychological factors themselves also influence the underlying mechanisms providing postural control. This experiment is not directly related to rehabilitation science, due to the fact that it investigated healthy controls. However, this kind of research is important to extend the research to different relevant pathologies. It emphasizes the importance of a broad biopsychological approach of the individual during examination as well as rehabilitation. In terms of treatment protocols, this findings could be especially valuable for patients with chronic low back pain, considering their difficulties with postural control and the influence of psychological factors. Thus, the dual functioning of the diaphragm in postural control and in respiratory functions should be taken into account in this population. Therefore, it should be considered to implement the psychological state and trait, postural control and respiratory functions into their treatment, due to the alleged interactions between these factors. Furthermore, it is expected that this could be applicable for several other conditions, in particular for chronic pain conditions. However, further investigation is necessary.

5.3. Strengths and weaknesses of this research

Several considerations concerning the strength and weaknesses should be taken into account. They will be declared in the following paragraphs.

5.3.1. Strengths

According to our knowledge, this is the first study to investigate the relationship between induced emotions, hyperventilation, psychological trait and state, COP, EMG and CO2 levels. The testing was performed in a controlled environment following a strict protocol to execute the testing for each participant in the exact same manner. Scripts were offered in a randomized order to rule out any influence of timing of the scripts. Another strength of this study is the equal distribution of males and females in our group of participants to avoid sex related differences. Participants had to fill in an extensive series of questionnaires to provide us with detailed information about their physical and psychological state so confounding factors could be ruled out.

5.3.2. Weaknesses

Several weaknesses can be reported. Regarding the attentional focus questionnaires, scores differ greatly from person to person and it appeared difficult to stay focused on the scripts. This might have led to less accurate results. Additionally the duration of the testing was quiet long, participants indicated that they found it harder to focus on the scripts towards the end of the testing. Moreover, due to the validation of the used scripts for patients with low back pain, it was hard for healthy controls to really empathize into the scripts because they have never experienced such situations. Also the scripts were the same for each individual, not taking into account individual differences in emotional response to certain situations. The importance of this individual approach is demonstrated in a study of Matheve, De Baets, Bogaerts and Timmermans (2019), who showed that task-specific measures of pain related fear could predict lumbar range of motions, but general measures could not. Thus, for further research it is indicated to use task-specific movements, which could be obtained by the Photograph Daily Activities Series-Short Electronic Version (PHODA-SeV). Besides that, due to the protocol of this study, it was impossible to blind the investigators. Therefore, while analysing the results, the subjects were anonymized by means of reference numbers to prevent any biases. The testings itself were conducted by six different investigators, which might have led to less uniformity in instructions. This was counteracted by a very specific

protocol every investigator had to study and follow throughout the completion of the testings. All 21 participants proceed from an active and young population, this may have led to selection bias and makes it difficult to generalize this finding into an older population. Another limitation concerning data collection is the fact that the used handheld capnograph did not measure solely end-tidal PetCO2 but a mean value of the last 2 seconds. Therefore a roughly estimation of mean PetCO2 values during a specific time stamp had to be made. Regarding the hyperventilation provocation test, the baseline PetCO2 level was 33.7, which is in the normal range. However, after the recuperation period of five minutes, the mean PetCO2 level was 31.8. This level is situated in the normal range as well, however it is not as high as the mean baseline level which might implicate that the recovery phase was not long enough to return to baseline levels. Furthermore, this study utilized COP and EMG measurements to analyse postural control. These are commonly used methods for postural control measurements, nevertheless researchers are questioning the accuracy of these techniques. Palliard and Noé (2015) stated that global COP variables, which were used in this study, are not sensitive enough to the structure of variation. However, these variations might provide essential insights into the postural control processes. Additionally, Robertson, Caldwell, Hamill, Kamen and Whittlesay (2004) stated that clearly EMG amplitude increased as the intensity of muscle contraction increased. Though, the relationship between EMG amplitude and force frequently appeared to be nonlinear. These concerns should be taken into account in further research. More sensitive COP variables should be used to detect small variations in postural control and EMG values should be evaluated in an non-linear way. Ultimately, EMG values of tibialis anterior and soleus were not taken into account, despite their well-reported correlation to postural control as well (Mulavara, Verstraete, & Simon, 1994; Müller & Redfern, 2004).

5.4 Recommendations for further research

For further research, it would be interesting to include muscle onset in the results as well, as this is an important factor to consider in postural control and stability. Furthermore, this research should be conducted in greater sample sizes and less uniform populations, so the findings would be more generalizable. Additionally, it would be very interesting to extend this research to more specific populations, such as patients with low back pain. When specifying this research into participants with low back pain, it might be recommended to use the PHODA

scale instead of the TSK-11. TSK-11 is rather unspecific, whereas the PHODA focuses on painful movements specific for low back pain. Furthermore, as previously described, more individually oriented scripts should be drafted to optimise the emphasising of the script which should lead to more accurate findings. The possible influence of the ankle strategy should be taken into account as well, as this is often used to compensate for difficulties in postural control. Additionally, it is recommended that functioning of the diaphragm on itself should be examined and measurements of heart rate variability and skin conduction should be conducted to assess the amount of provoked emotions.

6. Conclusion

This study indicates that imagery-induced emotions affect postural control, considering that the phase of the script had a significant influence on several center of pressure variables. Regarding the influence of the script content, most significant differences are found between the HR and R script. However, finding are inconsistent which leads to difficulties in concluding which script evoked the most difficulties in maintaining postural control. On trunk muscle activity and CO2 levels, no significant influence was found. Furthermore, voluntary hyperventilation significantly alters COP, EMG and CO2 levels. Ultimately, it is demonstrated that PetCO2 levels are correlated with the multidimensional perfectionism scale. No association between psychological trait and COP or EMG was found.

7. References

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8. Appendices

Appendix 1: Electrode placement

Muscle	EMG electrode placement
m. rectus abdominis	2 cm lateral to the umbilicus.
m. obliquus abdominis internus	2 cm medially and inferior to the anterior superior iliac spine.
m. erector spinae pars lumbalis	2 cm lateral to the spine at L3 vertebra level.
m. multifidus	Maximal 1 cm lateral to the spine at L4-L5.
m. intercostalis externus	At the 2nd or 3rd intercostal space, parasternal at the midclavicular line.
m. sternocleidomastoideus	On the sternal head, at the lower 1/3 of the line between the sternal notch and the mastoid attachment.
m. trapezius pars descendens	At 50% on the line from the acromion to the spine on vertebra C7.

Appendix 2: Content of scripts

Content of scripts	
Neutral	Ik ben in een appartement aan zee. Ik heb net mijn schoenen uitgedaan en ik zit nu op mijn gemak in de zetel. Ik luister met een half oor naar de radio. De vroege voorjaarszon schijnt door het raam naar binnen en hult mijn hele lichaam in een behaaglijke warmte. Ik kijk door het raam naar buiten en zie de zee. De zee is kalm. Het is vloed, maar het strand is nog redelijk groot. Enkele kinderen bouwen er zandkastelen. Ik zie enkele wandelaars en een hond voorbij lopen. Zij doen de meeuwen op het strand opvliegen.
Hostile resistance 1	Ik ben alleen thuis. De telefoon rinkelt: vrienden willen op bezoek komen... Oei, ik ben hier helemaal niet op voorbereid en ik heb al de hele dag zware rugpijn. Dit bezoek zal mij nog meer last bezorgen, maar het zou ook goed doen om mijn vrienden nog eens terug te zien. Mijn rugpijn verpest zoveel en verhindert mij te genieten van de kleine dingen in het leven. Ik kan de pijn maar niet uit mijn hoofd zetten. Ik voel frustratie opborrelen. Het is toch ook zo onrechtvaardig! Ik moet steeds maar vechten tegen mijn rugpijn en tegen de onzekerheid. Het is alsof het leven erop uit is om me te pakken. Het maakt me zo kwaad en opstandig. Ik zou het willen uitschreeuwen.
Acceptance 1	Ik ben alleen thuis. De telefoon rinkelt: vrienden willen op bezoek komen. Oei, ik ben hier helemaal niet op voorbereid en ik heb al de hele dag zware

	rugpijn. Dit bezoek zal mij nog meer last bezorgen, maar het zou ook goed doen om mijn vrienden nog eens terug te zien. Ik kan nog steeds genieten van de kleine dingen in het leven, ondanks de rugpijn. Laat mij dan maar pijn hebben, het is nu eenmaal zo en ik probeer er ook niet teveel mee bezig te zijn... Ik kijk uit naar de komst van mijn vrienden. Ik voel me innerlijk sterk en maak me geen zorgen over de rugpijn en mijn toekomst. Ik neem de dingen zoals ze komen.
Hostile resistance 2	Ik sta aan de kassa in een winkel. Er staat een hele rij mensen voor me aan te schuiven. Het lijkt wel uren te duren. Ik voel de rugpijn opkomen. Ik denk aan de hele weg die ik nog naar huis moet afleggen. Dit ga ik niet aankunnen, ik zal de komende dagen niets meer waard zijn! Een gevoel van wanhoop en irritatie komt opzetten… Ik moet immers voortdurend over mijn grenzen gaan, een enorme strijd leveren tegen de pijn., die ik maar niet kan winnen. Het is zo oneerlijk. Het is alsof het leven erop uit is om me te pakken. Het maakt me enorm kwaad en opstandig! Ik zou het wel kunnen uitschreeuwen.
Acceptance 2	Ik sta aan de kassa in een winkel. Er staat een hele rij mensen voor me aan te schuiven. Het lijkt wel uren te duren. Ik voel de rugpijn opkomen. Ik denk aan de hele weg die ik nog naar huis moet afleggen. Misschien ben ik de komende dagen hierdoor niets meer waard. Maar ik slaag erin me daarover op dit moment niet teveel zorgen te maken, dat heeft immers geen zin. De toekomst kan ik toch niet voorspellen. Ik leef van dag tot dag en probeer te genieten van de kleine dingen in het leven. Ik richt mijn aandacht nu weg van de pijn, naar een stralende lentezon die door het raam schijnt en alles laat glinsteren. Het geeft me een krachtig gevoel vanbinnen.
Relaxation	Zondagnamiddag thuis. In de meest comfortabele zetel zit ik lekker gemakkelijk een boek te lezen. Het is gezellig warm, er staat een geurige kop koffie naast mij. Af en toe leun ik achterover, en tuur ik door het raam. Het is een zonnige herfstdag buiten. Een kalm briesje blaast gele, rode en bruine bladeren van de bomen. Ze dwarrelen langzaam naar beneden. Een passerende auto doet af en toe de bladeren van de grond weer opwaaien. Het briesje neemt ze even mee. Enkele zondagswandelaars passeren voor mijn raam. Ik neem een slokje koffie en zet de kop weer terug op het tafeltje. Ik word weer opgeslorpt door het verhaal in mijn boek.

Appendix 3: Instruction for the imagery trials

Instructions:	*In the next phase of this research you will again be standing in a relaxed upright position on the force plate (with foam pad) with the non-transparent goggles on. You will get a headphone through which first one-minute of music will play. This will be followed by a brief text of about one minute which describes a situation. The purpose is to empathize as vivid as possible with the situation. This can be done not only by visualizing it, but also imagining that you are going through this situation yourself and trying to feel what you would feel in this situation. This is uttermost important. After the text is read, a period of one and a half minute of silence will be followed wherein you continue to imagine the end of the described situation as vividly as*

	possible. When piano music plays you can stop with the imagination but remain standing for another minute. You will first get a situation to practice. After that, three other situations will follow divided by a few minutes of rest. It is important to breathe through your nose throughout the whole trial.

Appendix 4: State questionnaires

Study ID:

Conditie:

Script:

Tijdens de verbeelding, wanneer u zich niet geheel kon concentreren op het scenario…

1. ⋯ heeft u bewust geprobeerd om specifieke delen van uw **lichaam of bewegingen te controleren**?

   Ja / Neen

2. ⋯ heeft u veel **aandacht** besteed aan de specifieke **instructies** die werden gegeven met betrekking tot de doelen van de taak zoals het behouden van een ontspannen houding,⋯?

   Ja / Neen

3. … heeft u zich **gefocus**t op gevoelens van **angst of zorgen**?

   Ja / Neen

4. ⋯ heeft u gebruik gemaakt van **strategieën** om **zelfverzekerd, kalm en/of gefocust** te blijven? (bv. Ademhaling gecontroleerd, bewust zichzelf afgeleid,⋯)

   Ja / Neen

5. ⋯ had u **gedachten** die **niet gerelateerd** waren aan de taak? (bv. Plannen na de studie, gesprekken met vrienden,⋯)

   Ja / Neen

Questionnaire attentional focus

Deze vragenlijst bestaat uit 39 klachten die u in het dagelijkse leven kan ervaren. Het is de bedoeling dat u voor elke klacht aangeeft in welke mate u ze **tijdens de inbeelding** ervaren hebt. U kan antwoorden door één van volgende antwoordalternatieven aan te kruisen: A=niet,B=een beetje, C=nogal, D=eerder sterk of E=zeer sterk

		A niet	**B een beetje**	**C nogal**	**D eerder sterk**	**E zeer sterk**
1.	Gespannenheid					
2.	Duizeligheid					
3.	Een snellere of diepere ademhaling					
4.	Gewrichtspijnen					
5.	Ademnood					
6.	Benauwd gevoel in en om de borst					
7.	Bonzen van het hart					
8.	Slaperig gevoel					
9.	Angstig gevoel					
10.	Gevoel van onrust, paniekerigheid					
11.	Zich warm voelen					
12.	Lage rugpijnen					
13.	Rillerigheid					
14.	Gevoel van warmte in het hoofd					
15.	Druk op keel, brok in keel					
16.	Verstopte neus					
17.	Tintelingen in armen					
18.	Tintelingen in gezicht					
19.	Verstikkingsgevoel					
20.	Branderig gevoel in de ogen					
21.	Hoofdpijn					
22.	Misselijkheid					
23.	Tintelingen in voeten					
24.	Onvoldoende diep kunnen doorademen					
25.	Snelle hartslag					
26.	Zwart worden voor de ogen					
27.	In de war zijn					
28.	Krampen in benen of tenen					
29.	Buik- of maagkrampen					
30.	Tintelingen in benen					
31.	Onregelmatige hartslag					

32.	Flauwvallen					
33.	Beven van de handen					
34.	Opgeblazen gevoel in buik/maag					
35.	Tintelingen in vingers					
36.	Pijnlijk gevoel in de borst, rond hartstreek					
37.	Stijf gevoel in vingers of armen					
38.	Huilbuien					
39.	Koude handen of voeten					

In welke mate hebt u zich tijdens de inbeelding werkelijk gevoeld zoals in het verhaal beschreven werd? Omcirkel een cijfervan 1 (zeer levendig) tot en met 9 (niet levendig).

1	2	3	4	5	6	7	8	9
Zeer levendig								niet levendig

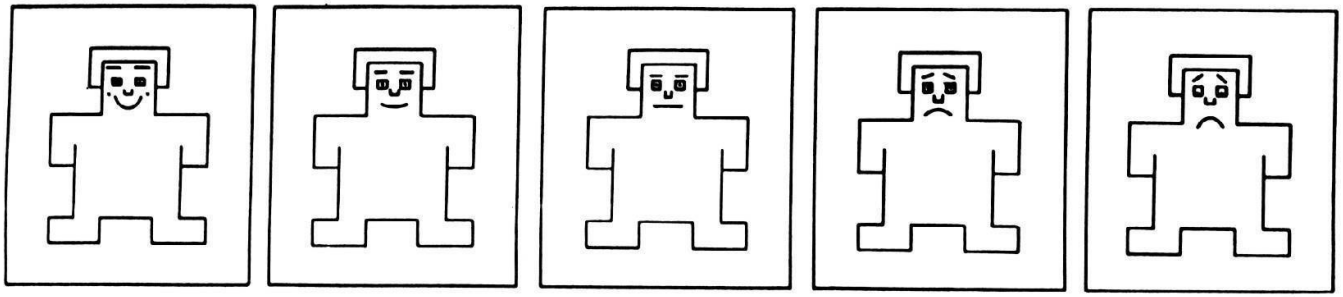
Hoeveel moeite hebt u moeten doen om u dit verhaal levendig in te beelden?

1	2	3	4	5	6	7	8	9
geen moeite				matig moeite				uiterst veel

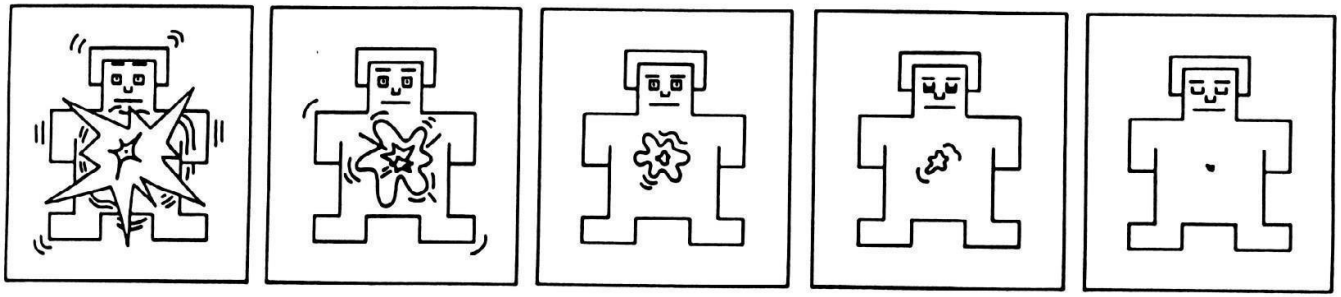
Hoeveel procent van de totale inbeeldingstijd (tekst + stilte) ben je er daadwerkelijk in geslaagd om je op het verhaal teconcentreren?

0% 100%

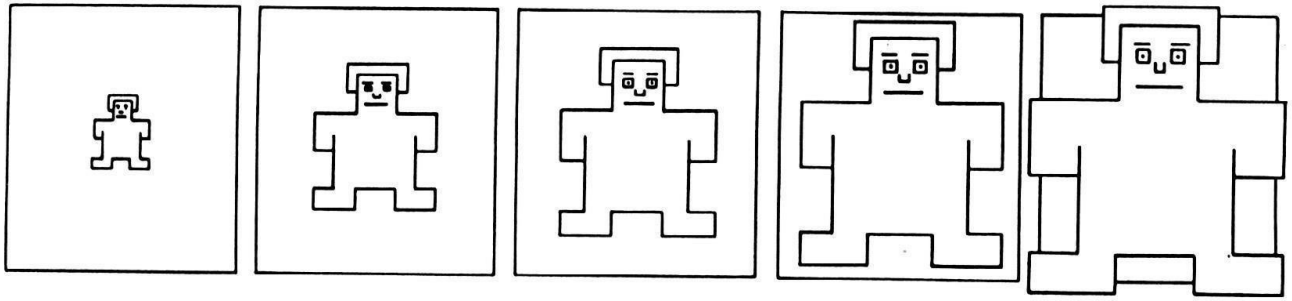
Hoe **aangenaam/onaangenaam** was de inbeelding?



Hoe **opgewonden/kalm** was u tijdens de inbeelding?



In welke mate had u tijdens de inbeelding het gevoel dat u **geen/wel controle** had over de situatie?



Positive And Negative Affect Schedule

Deze vragenlijst bestaat uit 20 woorden die gevoelens beschrijven. Duid bij elk woord aan in welke mate u zich tijdens de inbeelding zo voelt: A = heel weinig, B = een beetje, C= matig, D = veel, E = heel veel. U kan antwoorden door een kruisje in de kolom A, B, C, D of E te zetten.

		A heel weinig	**B een beetje**	**C matig**	**D veel**	**E heel veel**
1.	geïnteresseerd					
2.	bedroefd					
3.	opgewekt					
4.	teneergeslagen					
5.	sterk					
6.	schuldig					
7.	angstig					
8.	vijandig					
9.	enthousiast					
10.	zelfverzekerd					
11.	vlug geïrriteerd					
12	alert					
13	beschaamd					
14.	vol inspiratie					
15.	gespannen					
16.	vastberaden					
17.	aandachtig					

18	zenuwachtig					
19.	energiek					
20	bang					

In welke mate was u bezorgd om te vallen of het evenwicht te verliezen tijdensde taak die gevraagd werd? Omcirkel een cijfer van 1 (niet bezorgd) tot en met9 (zeer bezorgd).

1	2	3	4	5	6	7	8	9

Appendix 5: Results COP measurement phase 2 + 4

Pre-hyperventilation

	Hostile resistance			Acceptance			Relaxation		
	Baseline	**Imagery**	**Recovery**	**Baseline**	**Imagery**	**Recovery**	**Baseline**	**Imagery**	**Recovery**
COPmax AP (m)									
• **M**	0.01139	0.013499	0.01277	0.010628	0.014985	0.012873	0.01245	0.013064	0.013262
• **SD**	0.004762	0.003495	0.004037	0.003701	0.00476	0.003625	0.003732	0.003127	0.00746
COP max ML (m)									
• **M**	0.015113	0.019944	0.018264	0.014999	0.019956	0.020227	0.01578	0.021475	0.019801
• **SD**	0.004279	0.005687	0.004148	0.004387	0.004405	0.005724	0.004052	0.004588	0.007202
COPmaxvel AP (m/s)									
• **M**	0.015113	0.063762	0.058337	0.052849	0.067398	0.059736	0.054455	0.057742	0.06243
• **SD**	0.004279	0.025663	0.019204	0.018307	0.031998	0.0209	0.024704	0.021866	0.03649
COPmaxvel ML (m/s)									
• **M**	0.055857	0.098557	0.091014	0.081004	0.102672	0.101821	0.093215	0.102938	0.099293
• **SD**	0.020318	0.03813	0.027997	0.024895	0.029008	0.046956	0.026488	0.050615	0.055225
COPmeanvel AP (m/s)									
• **M**	0.009854	0.008879	0.009335	0.009109	0.008994	0.009511	0.009352	0.008423	0.009192
• **SD**	0.003577	0.003071	0.003474	0.003618	0.003696	0.003253	0.003732	0.002818	0.003426
COPmeanvel ML (m/s)									
• **M**	0.014796	0.013781	0.014737	0.014599	0.013786	0.014887	0.014852	0.013461	0.014268
• **SD**	0.005093	0.004436	0.004387	0.00484	0.003848	0.003521	0.004666	0.003855	0.004241
COPmin AP (m)									
• **M**	-0.0133	-0.01285	-0.0125	-0.01297	-0.01333	-0.01279	-0.01188	-0.01394	-0.0121
• **SD**	0.003916	0.004393	0.004347	0.004086	0.003807	0.00461	0.003676	0.003372	0.003623
COPmin ML (m)									
• **M**	-0.01758	-0.01897	-0.01669	-0.01718	-0.01926	-0.01808	-0.0181	-0.01982	-0.02095
• **SD**	0.004444	0.00373	0.00553	0.004262	0.006324	0.005102	0.005003	0.004761	0.012489
COPnormsway AP (m^2/s)									
• **M**	0.009854	0.008879	0.009335	0.009109	0.008994	0.009511	0.009352	0.008423	0.009192
• **SD**	0.003577	0.003071	0.003474	0.003618	0.003696	0.003253	0.003732	0.002818	0.003426

COPnormsway ML (m^2/s)									
• **M**	0.014796	0.013781	0.014737	0.014599	0.013786	0.014887	0.014852	0.013461	0.014268
• **SD**	0.005093	0.004436	0.004387	0.00484	0.003848	0.003521	0.004666	0.003855	0.004241
COPrms AP (m)									
• **M**	0.00462	0.004494	0.004822	0.00442	0.004345	0.005028	0.004391	0.004257	0.004858
• **SD**	0.001438	0.001079	0.001358	0.001512	0.001071	0.001323	0.00084	0.00088	0.001219
COPrms ML (m)									
• **M**	0.006474	0.006263	0.006954	0.005899	0.006093	0.00693	0.006168	0.006285	0.007319
• **SD**	0.001448	0.001344	0.001488	0.001205	0.001008	0.001436	0.001335	0.000959	0.002288
COPstd AP (m)									
• **M**	0.004158	0.004376	0.004416	0.004097	0.004246	0.004552	0.004048	0.004191	0.004354
• **SD**	0.00095	0.00103	0.001173	0.0015	0.001	0.000934	0.000853	0.000918	0.001179
COPstd ML (m)									
• **M**	0.005812	0.00609	0.006434	0.005522	0.005999	0.006586	0.005852	0.006214	0.006919
• **SD**	0.001106	0.001276	0.001448	0.001051	0.000987	0.001434	0.001072	0.000966	0.002429
COPswaypath AP (m)									
• **M**	0.580425	1.056645	0.45742	0.536549	1.070264	0.466042	0.550815	1.002307	0.450407
• **SD**	0.210688	0.365449	0.170211	0.213088	0.439818	0.159382	0.219816	0.335305	0.167879
COPswaypath ML (m)									
• **M**	0.871478	1.639919	0.722126	0.859886	1.64054	0.729474	0.874791	1.601909	0.699133
• **SD**	0.299982	0.527887	0.214969	0.285052	0.457958	0.172514	0.274822	0.45874	0.207813
COPswaypath Total (m)									
• **M**	1.051289	1.955393	0.857599	0.536549	1.070264	0.466042	1.037356	1.895031	0.834544
• **SD**	0.353688	0.627377	0.26489	0.213088	0.439818	0.159382	0.340618	0.549034	0.257527
Sway area (m^2)									
• **M**	0.000317	0.000354	0.000364	0.000299	0.00036	0.000394	0.000306	0.000364	0.000457
• **SD**	0.00012	0.000145	0.00015	0.000156	0.000149	0.000146	0.000103	0.000124	0.000369

Post-hyperventilation

	Hostile resistance			Acceptance			Relaxation		
	Baseline	**Imagery**	**Recovery**	**Baseline**	**Imagery**	**Recovery**	**Baseline**	**Imagery**	**Recovery**
COPmax AP (m)									
• **M**	0.0120154	0.0148835	0.0131088	0.0120467	0.0135108	0.0139234	0.0131102	0.0151165	0.0126113
• **SD**	0.0041004	0.0048383	0.0033683	0.003479	0.0040336	0.0077887	0.0061112	0.0064645	0.0050278
COPmax ML (m)									
• **M**	0.0165088	0.020576	0.0193612	0.0177983	0.0197454	0.0197249	0.0197621	0.0216716	0.0207917
• **SD**	0.004118	0.0049863	0.0041291	0.0040169	0.0046098	0.0063065	0.0125339	0.0097185	0.0100341
COPmaxvel AP (m/s)									
• **M**	0.0583414	0.059704	0.0493402	0.0580082	0.0586433	0.057565	0.068504	0.0630969	0.058756
• **SD**	0.0241651	0.0230704	0.0177215	0.02805	0.0218653	0.0311583	0.0843493	0.0463061	0.0404105
COPmaxvel ML (m/s)									
• **M**	0.0762238	0.0938699	0.0800444	0.0803467	0.0885512	0.0820264	0.0944681	0.0936013	0.0861845
• **SD**	0.0284952	0.0309126	0.0243222	0.0326858	0.0209529	0.0273891	0.1105344	0.054083	0.0445358
COPmeanvel AP (m/s)									
• **M**	0.0087641	0.0087284	0.008976	0.0091812	0.0088507	0.0092514	0.0103403	0.0097714	0.0099874
• **SD**	0.0033729	0.0030422	0.0028849	0.0037607	0.0032856	0.0040582	0.0085137	0.0083251	0.0074493
COPmeanvel ML (m/s)									
• **M**	0.0132946	0.0131377	0.0135024	0.0135331	0.0130369	0.0136443	0.0149205	0.0141208	0.0145519
• **SD**	0.0037509	0.0031365	0.0032111	0.0038205	0.0034862	0.0039047	0.0094581	0.0080436	0.0072303
COPmin AP (m)									
• **M**	-0.012923	-0.013945	-0.011042	-0.013224	-0.014017	-0.011774	-0.013444	-0.014682	-0.012664
• **SD**	0.0051684	0.0038872	0.0035482	0.0057702	0.0033866	0.0051669	0.0043413	0.0062805	0.0046304
COPmin ML (m)									
• **M**	-0.018155	-0.019526	-0.015464	-0.01799	-0.018976	-0.01764	-0.019387	-0.021925	-0.018723
• **SD**	0.0039739	0.004164	0.0045545	0.0071673	0.0038873	0.0055595	0.0076117	0.0096378	0.0070489
COPnormsway AP (m^2/s)									
• **M**	0.0087641	0.0087284	0.008976	0.0091812	0.0088507	0.0092514	0.0103403	0.0097714	0.0099874
• **SD**	0.0033729	0.0030422	0.0028849	0.0037607	0.0032856	0.0040582	0.0085137	0.0083251	0.0074493
COPnormsway ML (m^2/s)									
• **M**	0.0132946	0.0131377	0.0135024	0.0135331	0.0130369	0.0136443	0.0149205	0.0141208	0.0145519

• **SD**	0.0037509	0.0031365	0.0032111	0.0038205	0.0034862	0.0039047	0.0094581	0.0080436	0.0072303
COPrms AP (m)									
• **M**	0.0044804	0.0043701	0.0046744	0.0050023	0.0044018	0.0055419	0.0048505	0.0047649	0.0048839
• **SD**	0.001083	0.0010158	0.00099	0.0017299	0.0010351	0.0041974	0.0017545	0.0018226	0.001997
COPrms ML (m)									
• **M**	0.0066781	0.0064242	0.0066221	0.0066697	0.0065083	0.0070224	0.0070834	0.0070034	0.0072648
• **SD**	0.0013601	0.0011537	0.0009289	0.0017923	0.0014056	0.0019253	0.0027945	0.0033603	0.0026832
COPstd AP (m)									
• **M**	0.0042128	0.0043256	0.004268	0.0042938	0.0042838	0.0047416	0.0046392	0.0047049	0.0045393
• **SD**	0.0010834	0.0010352	0.0009641	0.0010412	0.0009935	0.0019942	0.0015941	0.0018153	0.0015566
COPstd ML (m)									
• **M**	0.0061165	0.006309	0.0061617	0.0063327	0.0063972	0.006588	0.0066746	0.0068559	0.0069465
• **SD**	0.0013789	0.0011443	0.0010939	0.0018324	0.0013989	0.0018367	0.0024151	0.0031744	0.0027975
COPswaypath AP (m)									
• **M**	0.5162039	1.0386838	0.4398237	0.5407717	1.0532375	0.4533209	0.6090456	1.1628007	0.4893831
• **SD**	0.1986627	0.3620221	0.1413593	0.2215036	0.3909889	0.1988518	0.5014595	0.9906918	0.3650173
COPswaypath ML (m)									
• **M**	0.783053	1.5633856	0.6616157	0.7970985	1.5513858	0.668571	0.8788169	1.6803716	0.713042
• **SD**	0.2209277	0.3732481	0.1573424	0.2250302	0.4148618	0.1913282	0.5570825	0.9571885	0.3542855
COPswaypath Total (m)									
• **M**	0.5162039	1.0386838	0.4398237	0.967411	1.8806849	0.8122942	1.0734608	2.0551643	0.8694126
• **SD**	0.1986627	0.3620221	0.1413593	0.302017	0.5505184	0.2616237	0.7431602	1.3591677	0.5004045
Sway area (m^2)									
• **M**	0.0003352	0.0003772	0.0003362	0.003677	0.0003653	0.0004004	0.0004345	0.0005007	0.0004347
• **SD**	0.0001328	0.0001476	0.0001256	0.0001904	0.0001302	0.000211	0.0004389	0.0005325	0.0003646

M = mean, SD = standard deviation COP = center of pressure, AP = anterior-posterior, ML = medial-lateraal, max = maximal activity, maxvel = maximal velocity, meanvel = mean velocity, min = minimal activity, normsway = time-normalized sway path, rms = root mean square, std = standard deviation, swaypath = total sway path

Appendix 6
Results EMG measurement phase 2 + 4

Pre-hyperventilation

	Hostile resistance			Acceptance			Relaxation		
	Baseline	**Imagery**	**Recovery**	**Baseline**	**Imagery**	**Recovery**	**Baseline**	**Imagery**	**Recovery**
M. Rectus abdominis									
• **M**	4.699602	4.5026245	4.509599	4.6754403	4.5208972	4.5397048	4.7190149	4.5336118	4.5594433
• **SD**	4.339586	4.4027554	4.4091961	4.3511806	4.3849916	4.3057952	4.4144262	4.4258632	4.4537407
M. Obliquus abdominis internus									
• **M**	6.8428075	6.7256226	6.8131781	6.742926	6.9640245	6.9337415	6.6417375	6.6179859	6.6490304
• **SD**	5.9468292	5.6505778	6.3135289	6.3943061	6.4085995	6.2553948	6.5060883	6.1424303	5.9894657
M. Erector spinae pars lumbalis									
• **M**	5.2753061	5.6776198	5.7951517	5.6142323	5.5414345	5.6340242	5.64629	5.4379891	5.0982507
• **SD**	4.6352546	5.035704	4.9562721	4.4987268	4.7388116	5.2114711	5.0794933	4.6239229	4.1956667
M. Multifidus									
• **M**	6.5531969	6.695332	6.7067008	9.6647404	8.2508912	7.6564511	6.8673125	6.1393981	5.6535229
• **SD**	5.9744494	6.3379287	6.4629558	14.685149	10.076844	8.7149703	6.8609315	6.0973913	5.6078562
M. Intercostalis externus									
• **M**	2.5783937	2.560964	2.5114468	2.6218992	2.7420261	2.7996486	2.6181425	2.549295	2.5802754
• **SD**	2.329841	2.205199	2.0182212	2.1070786	2.1523458	2.1008649	2.4595004	1.9840224	1.969381
M. Sternocleidomastoideus									
• **M**	2.6060402	2.4518293	2.4305667	2.5436391	2.7971395	2.7903398	2.3900112	2.4000759	2.3713479
• **SD**	3.2289887	3.0851624	3.0395468	2.8819505	3.326026	3.2774876	3.1273827	3.1718212	3.0171101
M. Trapezius pas descendens									
• **M**	2.5947603	2.6348594	2.5289322	3.0124354	2.9950654	2.7694192	2.6961547	2.6587565	2.6101314
• **SD**	2.2661049	2.4174734	2.3631071	2.457981	2.4602166	2.4203586	1.9965815	2.0314149	2.1793393

Post-hyperventilation

	Hostile resistance			Acceptance			Relaxation		
	Baseline	Imagery	Recovery	Baseline	Imagery	Recovery	Baseline	Imagery	Recovery
M. Rectus abdominis									
• **M**	4.3704974	4.2274301	4.2577692	4.3682386	4.2314638	4.2524439	4.3329820	4.2574259	4.2842903
• **SD**	4.0410046	4.0953341	4.1423470	4.0775192	4.1176611	4.0856111	4.0005589	4.0844040	4.1181948
M. Obliquus abdominis internus									
• **M**	7.4430787	7.8666785	7.6109511	8.2397767	8.2621937	8.2538771	7.5673524	7.5564848	7.2568956
• **SD**	8.7937372	10.065837	9.3909108	9.1177689	8.703217	9.269839	8.5485301	8.59496	8.8449826
M. Erector spinae pars lumbalis									
• **M**	5.0185675	4.9220961	4.9827475	5.1021564	5.2242664	5.5290038	4.6002487	4.6799149	4.7671913
• **SD**	4.7331475	4.7830164	4.9850076	5.7022319	5.2776328	6.2153375	4.0130385	4.1068159	4.0303852
M. Multifidus									
• **M**	5.2290402	5.3303267	5.0611909	5.1679632	5.2169593	5.0712809	4.6489987	4.4804431	4.2032358
• **SD**	6.0237884	6.5121469	5.9857529	6.5560222	6.5121718	6.4127598	5.4155301	5.0989509	4.5381598
M. Intercostalis externus									
• **M**	2.3819876	2.3939925	2.465157	2.3292773	2.4160136	2.426295	2.3609773	2.3361252	2.3507951
• **SD**	1.6168288	1.5277636	1.5454795	1.4697973	1.3584674	1.4326259	1.4363749	1.386883	1.3890008
M. Sternocleidomastoideus									
• **M**	2.4563716	2.7042194	2.6928756	2.345025	2.3261201	2.3838892	2.3439672	2.3196805	2.2913929
• **SD**	2.8353038	3.0270131	3.1061232	2.8004245	2.8275938	2.8959493	2.7983116	2.737347	2.6422756
M. Trapezius pars descendens									
• **M**	2.5711168	2.6037166	2.7845924	2.8105995	2.8552325	2.8051931	2.8063445	2.9235311	2.9455467
• **SD**	2.3758721	2.3316361	2.4218867	2.1019325	1.9270533	1.8250278	2.602407	2.8354229	2.8807941

M = Mean, SD = Standard Deviation, M. = Musculus

Appendix 7

Results CO2 measurement phase 2 + 4

Pre-hyperventilation

	Hostile resistance			Acceptance			Relaxation		
	Baseline	**Imagery**	**Recovery**	**Baseline**	**Imagery**	**Recovery**	**Baseline**	**Imagery**	**Recovery**
Mean PetCO2									
• **M**	34.137931	33.874561	33.425263	33.874773	33.376316	33.206316	33.351724	33.816667	33.578
• **SD**	2.3321723	2.1925123	2.0373495	2.2050163	2.2842882	2.4649098	2.29169	2.4952176	2.3759311

Post-hyperventilation

	Hostile resistance			Acceptance			Relaxation		
	Baseline	**Imagery**	**Recovery**	**Baseline**	**Imagery**	**Recovery**	**Baseline**	**Imagery**	**Recovery**
Mean PetCO2									
• **M**	32.815517	32.500877	32.581053	33.062069	33.371667	33.334	32.777586	33.15	32.838
• **SD**	3.9459118	3.8107769	3.1708497	2.1522732	1.9729761	2.4092899	2.9751558	3.0711209	3.2230349

M = Mean, SD = Standard Deviation, PetCO2 = end tidal carbon dioxide pressure

Appendix 8

Results questionnaire scores phase 2 + 4

Pre-hyperventilation

	Hostile resistance	Acceptance	Relaxation
AFQ			
• **M**	1.9	1.5	1.6
• **SD**	1.3	1.3	1.3
Likert 1			
• **M**	5.1	4.6	3.9
• **SD**	2.0	1.9	1.9
Likert 2			
• **M**	6.4	4.9	4.6
• **SD**	2.1	2.2	2.2
Likert 3			
• **M**	63.1	69.1	73.7
• **SD**	24.7	22.3	15.9
DLKL			
• **M**	43.6	41.8	41.5
• **SD**	5.2	2.3	2.2
PANAS TOTAL			
• **M**	37.3	40.7	38.5
• **SD**	7.0	7.7	6.1
PANAS POS			
• **M**	20.7	25.9	24.9
• **SD**	6.2	6.9	6.5

PANAS NEG			
• **M**	16.7	14.7	13.6
• **SD**	4.1	4.5	3.5
FOF			
• **M**	2.6	3	2.9
• **SD**	1.6	1.7	1.8
MANIKIN 1			
• **M**	6.1	3.4	2.1
• **SD**	1.7	1.4	1.1
MANIKIN 2			
• **M**	5.7	6.9	8
• **SD**	2.5	2.0	1.9
MANIKIN 3			
• **M**	5.6	7.4	8
• **SD**	2.5	1.1	1.2

Post-hyperventilation

	Hostile resistance	**Acceptance**	**Relaxation**
AFQ			
• **M**	1.6	1.4	1.4
• **SD**	1.4	1.2	1.3
Likert 1			
• **M**	4.8	4.5	3.8
• **SD**	1.8	2.0	2.1
Likert 2			
• **M**	5.8	5.2	4.5
• **SD**	1.9	2.0	2.2

Likert 3			
• **M**	66.7	67.5	68.6
• **SD**	22.1	21.7	17.8
DLKL			
• **M**	43.4	41.4	41.4
• **SD**	4.6	2.2	1.8
PANAS TOTAL			
• **M**	37.5	40.5	38
• **SD**	8.3	9.1	7.6
PANAS POS			
• **M**	19.5	25.3	24.6
• **SD**	6.7	7.1	7.9
PANAS NEG			
• **M**	18.1	15.2	13.4
• **SD**	4.8	4.9	3.8
FOF			
• **M**	2.6	2.5	2.6
• **SD**	1.3	1.2	1.3
MANIKIN 1			
• **M**	6.6	3.4	1.9
• **SD**	1.7	1.4	1.2
MANIKIN 2			
• **M**	5.4	7.1	8.1
• **SD**	2.2	1.6	1.1

MANIKIN 3			
• **M**	5.7	6.6	7.9
• **SD**	1.9	1.6	1.1

AFQ = Attentional Focus Questionnaire, DLKL = Dagelijkse Leven Klachten Lijst, PANAS TOTAL = Positive and Negative Affect Scale - total, PANAS POS = Positive and Negative Affect Scale – positive subscale, PANAS NEG = Positive and Negative Affect Scale – negative subscale, FOF = Fear of Falling

Appendix 9: Individual AFQ scores

	PREHYP			POSTHYP			MEAN
	HR	ACC	R	HR	ACC	R	
1	2	3	3	2	1	2	2
2	3	3	3	3	2	3	2.8
3	1	2	0	1	1	1	1
4	0	1	1	1	1	1	0.8
5	2	1	1	0	1	0	0.8
6	0	0	0	0	0	0	0
7	3	1	1	0	1	1	1.17
8	2	2	2	2	2	2	2
9	2	2	3	2	2	2	2.2
10	4	3	3	3	2	2	2.8
11	0	1	1	1	1	0	0.7
12	2	1	3	1	2	2	1.8
13	0	0	0	0	0	0	0
14	2	1	0	1	0	1	0.8
15	1	0	1	1	1	1	0.8
16	4	4	4	4	4	4	4
17	3	1	2	5	1	4	2.7
18	1	0	1	1	0	0	0.5
19	3	1	1	2	3	1	1.8
20	4	4	3	3	4	3	3.5
21	1	0	0	0	0	0	0.2

AFQ = Attentional Focus Questionnaire, PREHYP = pre-hyperventilation condition (C2), POSTHYP = post-hyperventilation condition (C4), HR = Hostile-Resistance imagery script, ACC = Acceptance imagery script, R = Relaxation imagery scri

Appendix 10: **Baseline PetCO2 levels, minimal PetCO2 levels and recovery time**

Subject	Mean baseline PetCO2 (mmHg)	Minimal PetCO2 (mmHg) after HV	Recovery time (s)
1	34.9	20.6	5min
2	34.0	33.6	3min
3	33.6	32.0	4min
4	34.5	26.0	/
5	35.2	26.2	/
6	32.4	26.0	4min
7	34.9	31.3	/
8	34.8	34.4	1min
9	28.8	26.0	4min
10	30.8	20.6	/
11	33.0	23.7	4min
12	36.6	30.0	/
13	34.5	27.7	/
14	33.6	23.2	/
15	28.2	21.2	/
16	35.6	30.6	4min
17	31.9	24.1	4min
18	34.0	30.0	3min
19	34.8	30.8	/
20	37.3	19.1	/

PetCO2 = end tidal CO2 pressure, HV = hyperventilation, / = subjects did not reach baseline values during 5 minute recovery period

Inschrijvingsformulier verdediging masterproef academiejaar 2020-2021,
Registration form jury Master's thesis academic year 2020-2021,

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Faculteit/School: **Faculteit Revalidatiewetenschappen**
Faculty/School: ***Rehabilitation Sciences***

Stamnummer + naam: **1643682 Schrijvers Charlotte**
Student number + name

Opleiding/*Programme*: **2 ma revalid. & kine kinderen**

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/:

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O wijzigen - *change to:*

In geval van samenwerking tussen studenten, naam van de medestudent(en)/*In case of group work, name of fellow student(s)*:

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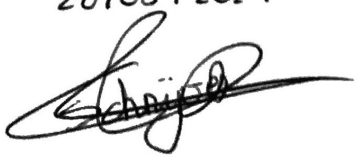
Datum en handtekening student(en)
Date and signature student(s)

28/05/2021



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Faculty/School: ***Rehabilitation Sciences***

Stamnummer + naam: **1334028 Van Wesemael Sofie**
Student number + name

Opleiding/*Programme*: **2 ma revalid. & kine musc.**

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Date and signature student(s)

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DATUM	INHOUD OVERLEG	HANDTEKENINGEN
18/08 - 04/09	Testdagen - Data verzameling	Promotor: Copromotor/Begeleider: Student(e): Student(e):
04/09 - 29/10	Opstellen statistisch plan + O2 vragen	Promotor: Copromotor/Begeleider: Student(e): Student(e):
29/10 - 29/12	Dataverwerking	Promotor: Copromotor/Begeleider: Student(e): Student(e):
29/12 - 27/02	Statistiek	Promotor: Copromotor/Begeleider: Student(e): Student(e):
27/02	Inleiding (1e draft)	Promotor: Copromotor/Begeleider: Student(e): Student(e):
14/03	Methode (1e draft)	Promotor: Copromotor/Begeleider: Student(e): Student(e):
26/04	Resultaten (1e draft)	Promotor: Copromotor/Begeleider: Student(e): Student(e):
14/05	Discussie (1e draft)	Promotor: Copromotor/Begeleider: Student(e): Student(e):
24/05	Volledige MP	Promotor: Copromotor/Begeleider: Student(e): Student(e):
31/05	Advies tot indienen	Promotor: Copromotor/Begeleider: Student(e): Student(e):

In te vullen door de promotor(en) en eventuele copromotor aan het einde van MP2:

Naam Student(e): Sofie Van Wesemael **Datum:** 26/05/21

Titel Masterproef: The effect of script driven imagery of emotions, and hyperventilation on center of pressure, end-tidal carbon dioxide and trunk muscle activation during postural control

1) Geef aan in hoeverre de student(e) onderstaande competenties zelfstandig uitvoerde:
   - NVT: De student(e) leverde hierin geen bijdrage, aangezien hij/zij in een reeds lopende studie meewerkte.
   - 1: De student(e) was niet zelfstandig en sterk afhankelijk van medestudent(e) of promotor en teamleden bij de uitwerking en uitvoering.
   - 2: De student(e) had veel hulp en ondersteuning nodig bij de uitwerking en uitvoering.
   - 3: De student(e) was redelijk zelfstandig bij de uitwerking en uitvoering
   - 4: De student(e) had weinig tot geringe hulp nodig bij de uitwerking en uitvoering.
   - 5: De student(e) werkte zeer zelfstandig en had slechts zeer sporadisch hulp en bijsturing nodig van de promotor of zijn team bij de uitwerking en uitvoering.

Competenties	**NVT**	**1**	**2**	**3**	**4**	**5**
Opstelling onderzoeksvraag	O	O	O	O	O	O
Methodologische uitwerking	O	O	O	O	O	O
Data acquisitie	O	O	O	O	O	O
Data management	O	O	O	O	O	O
Dataverwerking/Statistiek	O	O	O	O	O	O
Rapportage	O	O	O	O	O	O

2) <u>Niet-bindend advies:</u> Student(e) krijgt toelating/geen toelating (schrappen wat niet past) om bovenvermelde Wetenschappelijke stage/masterproef deel 2 te verdedigen in bovenvermelde periode. Deze eventuele toelating houdt geen garantie in dat de student geslaagd is voor dit opleidingsonderdeel.

3) Deze wetenschappelijke stage/masterproef deel 2 mag wel/niet (schrappen wat niet past) openbaar verdedigd worden.

4) Deze wetenschappelijke stage/masterproef deel 2 mag wel/niet (schrappen wat niet past) opgenomen worden in de bibliotheek en docserver van de UHasselt.

Datum en handtekening Student(e)	Datum en handtekening promotor(en)	Datum en handtekening Co-promotor(en)

In te vullen door de promotor(en) en eventuele copromotor aan het einde van MP2:

Naam Student(e): Charlotte Schrijvers **Datum:** 28/05/2021

Titel Masterproef: The effect of script driven imagery of emotions and hyperventilation on center of pressure, trunk muscle activation and end-tidal carbon dioxide during postural control

1) Geef aan in hoeverre de student(e) onderstaande competenties zelfstandig uitvoerde:
   - NVT: De student(e) leverde hierin geen bijdrage, aangezien hij/zij in een reeds lopende studie meewerkte.
   - 1: De student(e) was niet zelfstandig en sterk afhankelijk van medestudent(e) of promotor en teamleden bij de uitwerking en uitvoering.
   - 2: De student(e) had veel hulp en ondersteuning nodig bij de uitwerking en uitvoering.
   - 3: De student(e) was redelijk zelfstandig bij de uitwerking en uitvoering
   - 4: De student(e) had weinig tot geringe hulp nodig bij de uitwerking en uitvoering.
   - 5: De student(e) werkte zeer zelfstandig en had slechts zeer sporadisch hulp en bijsturing nodig van de promotor of zijn team bij de uitwerking en uitvoering.

Competenties	**NVT**	**1**	**2**	**3**	**4**	**5**
Opstelling onderzoeksvraag	O	O	O	O	O	O
Methodologische uitwerking	O	O	O	O	O	O
Data acquisitie	O	O	O	O	O	O
Data management	O	O	O	O	O	O
Dataverwerking/Statistiek	O	O	O	O	O	O
Rapportage	O	O	O	O	O	O

2) <u>Niet-bindend advies:</u> Student(e) krijgt toelating/geen toelating (schrappen wat niet past) om bovenvermelde Wetenschappelijke stage/masterproef deel 2 te verdedigen in bovenvermelde periode. Deze eventuele toelating houdt geen garantie in dat de student geslaagd is voor dit opleidingsonderdeel.

3) Deze wetenschappelijke stage/masterproef deel 2 mag wel/niet (schrappen wat niet past) openbaar verdedigd worden.

4) Deze wetenschappelijke stage/masterproef deel 2 mag wel/niet (schrappen wat niet past) opgenomen worden in de bibliotheek en docserver van de UHasselt.

Datum en handtekening Student(e)	Datum en handtekening promotor(en)	Datum en handtekening Co-promotor(en)

Lotte JANSSENS
aan mij, Charlotte

vr 28 mei 20:18 (3 dagen geleden)

Beste Sofie en Charlotte,

Hierbij de formele goedkeuring van jullie ingestuurde documenten: inventarisatieformulier en inschrijvingsformulier verdediging (akkoord met wijziging titel en niet-bindend advies om te verdedigen).
Succes met de laatste rechte lijn.

Mvg,

Lotte Janssens

Op vr 28 mei 2021 om 11:41 schreef Sofie Van Wesemael <sofie.vanwesemael@student.uhasselt.be>:

•••

Beantwoorden | Allen beantwoorden | Doorsturen