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Influence of Maintenance of Face-Down Positioning on Physiological and Psychological Factors

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Abstract:

Background: The purpose of this study was to investigate the influence of maintenance of Face-down positioning (FDP) on physiological and psychological responses of patients who require FDP after vitrectomy. **Methods:** The study included 22 healthy volunteers (21.9±2.6 years old) and two conditions: maintenance of FDP or maintenance of the sitting chair positioning (SCP). Study participants were evaluated for Profile of Mood States (POMS), subjective pain, blood pressure, heart rate, heart rate variability, shoulder muscle rigidity, skin temperature, and skin blood flow. **Results:** The change in POMS "fatigue" score before and after positioning was significantly greater in FDP than in SCP. Subjective pain increased over time in both FDP and SCP, but the increase was more pronounced in FDP and an interaction was observed between the neck and shoulders. Shoulder skin temperature decreased significantly over time in both FDP and SCP. In contrast, back skin temperature increased significantly in SCP, but decreased significantly in FDP. **Conclusions:** The psychological and physiological burdens are significant in FDP. Our results suggest that proactive support for relieving pain and promoting blood flow from the neck to the back region may be helpful in patients maintaining FDP.

Key words:

Face-down positioning, Chair sitting positioning, After vitrectomy, Young healthy adults

Background

Face-down positioning (FDP) is a common posture assumed when using a laptop computer or smartphone. However, FDP is burdensome; flexing the neck 15-60 degrees for long periods of time appears to cause chronic neck and shoulder pain in computer and smartphone users[1,2)].

On the other hand, patients with retinal diseases such as retinal detachment and macular holes are often forced to maintain FDP after vitrectomy. Vitrectomy often involves intraocular tamponade using expansible gases such as sulfur hexafluoride (SF6) or propane octafluoride (C3F8), and FDP is required to buoy the gas to mechanically push the retina into the pigment epithelium after surgery[3-5)]. Recently, the duration of FDP after vitrectomy was shortened after it was reported that FDP is an intense burden for patients, but maintenance of FDP for as long as 10 days is still recommended[6-9)].

Several studies have reported that patients who must maintain FDP complain of physical pain including headaches, neck pain, shoulder pain, and backache, as well as mental pain including anxiety, stress, and sleeplessness[10,11)]. Some strategies to reduce the pain caused by FDP include assistance devices such as pillows and desks[12,13)], and aromatherapy massage can reduce short-term FDP-related neck and shoulder pain[4)]. However, no concrete investigations have examined how FDP influences the physiological and psychological responses of patients after vitrectomy. We thus sought to evaluate the effectiveness of mitigation methods based on both subjective and objective measures.

The purpose of this study was to investigate the physiological and psychological responses of patients who must maintain FDP after vitrectomy.

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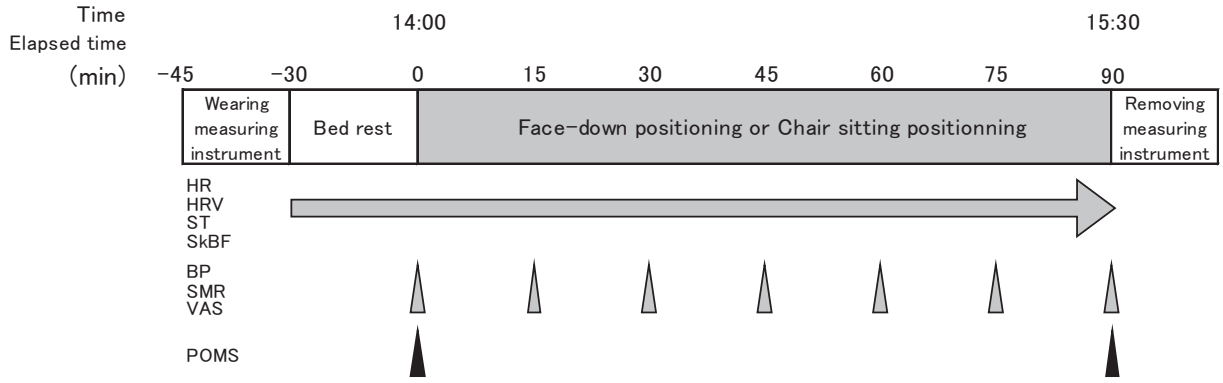

Figure 1. Experimental procedure
BP; Blood pressure, HR; Heat rate, HRV; Heart Rate Variability, POMS; Profile of Mood States, SMR; Shoulder muscle rigidity, SkBF; Skin Blood flow, ST; Skin temperature, VAS; Visual analog scale

Methods

This study was conducted between August and December 2014 in the Department of Medicine, Saga University (room temperature 26.4±0.6 degrees Celsius, humidity 49.6±6.3%, mean±SD). The study was conducted according to the declaration of Helsinki and was approved by the ethical Committee of the Department of Medicine, Saga University. Written informed consent was obtained from all participants.

Participants

The peak incidence of retinal detachment, which is an indication for vitrectomy, occurs in the 3rd and 7th decades of life[14-16], so this study targeted adults in their 20s. Healthy adult volunteers were recruited via poster and flyer. Inclusion criteria included the following: 1) clear understanding of the study instructions, 2) physically independent, 3) able to maintain a static position, 4) no use of cardiovascular medications, and 5) no wounds, disorders, or pain in the neck, shoulder, waist, or hip joints. Participants were instructed to sleep well the night before the test, and avoid high-intensity physical activity, alcohol, smoking, and excessive eating and drinking the day before and the day of the test. Participants were instructed to stop oral intake two hours before the test. Participants self-declared compliance with the instructions prior to testing. Power calculations, estimated from our previous study using change in subjective pain as the primary outcome, indicated that 24 volunteers were required to observe a significant between-group difference. However, two people were excluded after the interview, and 22 subjects participated in the study (11 males: 22.6±2.6 years old, height 167.3±6.0, body weight 61.5±6.3 kg, 11 females: 21.1±2.4 years old, height 158.7±4.9 cm, body weight 54.1±7.3 kg).

Positioning

In a crossover design, all participants were required to complete two days of testing. Maintenance of FDP or sitting chair positioning (SCP) occurred on different days, and the order of the conditions was randomly assigned. As shown in **Figure 1**, participants wore the same garments (100% cotton T-shirt and clothing) and measuring instruments. Each participant rested 30 minutes and then held their assigned posture for 90 minutes. Heart rate (HR), heart rate variability (HRV), skin temperature, and skin blood flow rate were measured continuously, while blood pressure (BP), shoulder muscle rigidity, and visual analog scale (VAS) were measured every 15 minutes from baseline (0 minutes) to 90 minutes. The Profile of Mood States (POMS) was completed at baseline and 90 minutes later. In FDP, participants sat at the edge of a bed with their head on a cushion placed on the over-bed table. In SCP, participants sat in a chair and watched a DVD(Ocean world, Jean-Jacques Mantell, 2012) with playback equipment placed on the over-bed table.

Psychological Assessment

In this study, the brief Japanese version of POMS (Kaneko Shobo, Japan) and subjective pain with VAS were used as psychological evaluations before and after the protocol. POMS is a popular tool used widely among psychologists and scientists from many fields that consists of six mood-state factors constituting affect, represented by six subscales: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor, Fatigue, and Confusion. Participants were asked to answer 30 questions on current mood using a 5-point scale ranging from 0 (not at all) to 4 (extremely). They were also asked to indicate pain in the neck, shoulder, and back using a 10-point scale ranging from 0 (no pain at all) to 10 (unacceptable pain) in a continuous 10-cm VAS.

Heart rate and heart rate variability

HR was calculated using the HRV analysis program (MEMcalc/TARAWA; GMS, Japan) by capturing the RR interval on an electrocardiogram obtained from the HR monitor (BSM-2401; NIHONKODEN, Japan) at a sampling interval of 250 Hz. The average HR was calculated every minute. HRV was calculated by frequency analysis based on the maximum entropy method using the same HRV analysis program. The target frequency was 0.04 to 0.40 Hz, and the high-frequency component (HF) (0.15 to 0.40 Hz), low-

frequency component (LF) (0.04 to 0.15 Hz), and component ratios between LF and HF (LF/HF) were obtained every minute. The HF component was used as an index of parasympathetic activity and LF / HF was used as an index of sympathetic nerve activity[17-19].

Blood pressure

BP was measured on the upper arm by sphygmomanometer (HEM-7210; Omron, Japan).

Shoulder muscle rigidity

Muscle rigidity of the right and left shoulder regions was measured by a muscle rigidity meter (NEUTONE TDM-Z1, TRY-ALL, Japan) midway between the right and left neck bottom and the seventh cervical vertebra, and a bilateral mean was calculated every 15 minutes.

Skin blood flow

Skin blood flow in the back (midpoint of the line connecting the left iliac crest and the spine) and in the left shoulder (scapula) was measured by laser Doppler flowmetry (ALF-21, ADVANCE, Japan) every 15 minutes during the study.

Skin temperature

Skin temperature was measured by thermistor probes at four body sites: right and left shoulder (scapula), and right and left back (midpoint of the line connecting the iliac crest and spine). Skin temperature was monitored every minute by a data logger (LT-8A, Gram Corporation, Japan), and the left and right temperatures were averaged every 15 minutes.

Statistical analysis

Data were analyzed using IBM SPSS Statistics version 22. All data are expressed as the mean±standard deviation, and $P<0.05$ was considered significant. A paired t-test was used to compare the POMS scores before and after the study, and Student's t-test was used to compare the change in POMS scores before and after the study. For time course analyses, average values were assessed at baseline, and at 15, 30, 45, 60, 75, and 90 minutes. Physiological indices were calculated as the ratio of each time point relative to baseline, and VAS scores were calculated as the difference between each time point and baseline. The time course was analyzed with a repeated-measures one-way analysis of variance (ANOVA), and differences between baseline and each point were evaluated by Dunnett's one-to-many post-hoc test. Comparison of the time course between the two conditions was analyzed by a two-way repeated measure ANOVA, and comparisons at each point were made using Student's t-test with the Bonferroni correction.

Results

POMS

The "Tension-Anxiety" score was significantly lower after the positioning test ($P=0.023$) in SCP (**Figure 2**). The "Vigor" score was significantly lower after the positioning test in both FDP and SCP ($P<0.001$ in both). The "Fatigue" score was significantly higher after the positioning test in both FDP and SCP ($P<0.001$ and $P=0.003$, respectively). Finally, the change in "Fatigue" score was significantly higher in FDP than in SCP ($P=0.027$).

Subjective pain (VAS)

The subjective pain time course is shown in **Figure 2**. In the neck, shoulder, and back region, VAS scores significantly increased over time in both FDP and SCP ($P<0.001$ in all cases). In the neck and shoulder, significant interactions ($P<0.001$ and $P=0.013$, respectively) were observed between position and time course. Significant differences were found between positions at each point from 15 to 90 minutes in the neck, and from 15 and 60 minutes in the shoulder. In the back region, no significant interaction was observed ($P=0.434$).

HR and HRV

Baseline HR was 69.7±7.7 beats per minute (bpm) in FDP and 67.81±7.7 bpm in SCP. HR in FDP slightly increased from baseline to 90 minutes (ratio 1.04, HR at 90 minutes 72.8±15.4 bpm), but did not significantly change over time. Likewise, HR in SCP slightly increased from baseline to 90 minutes (ratio 1.08, HR at 90 minutes 73.1± 16.5 bpm), but did not significantly change over time. There was no significant interaction between position and time course ($P=0.404$) (see **Figure 3**).

Baseline HF was 736.6±627.7 $msec^2$ in FDP and 917.0± 1080.3 $msec^2$ in SCP, and LF/HF was 2.8±2.4 in FDP and 2.5±1.7 in SCP. The HRV time course is shown in **Figure 3**. HF in SCP significantly decreased ($P=0.001$) over time. An interaction was observed between position and time course ($P=0.008$). There were significant differences between FDP and SCP at 30 minutes ($P=0.012$). LF / HF significantly increased in SCP ($P=0.001$) over time, and an interaction was observed between position and time course ($P=0.016$). Likewise, there were significant differences between FDP and SCP at 90 minutes ($P<0.001$).

Blood pressure (BP)

Baseline systolic BP was 104.3±10.5 mmHg in FDP and 108.9±12.3 mmHg in SCP, and baseline diastolic BP was 61.3±6.1 mmHg in FDP and 61.9±7.5 mmHg in SCP. As shown in **Figure 3**, systolic BP initially decreased and then increased in both FDP and SCP ($P=0.003$ and $P=0.001$, respectively), but there were no significant interactions between position and time course ($P=0.280$). Likewise, diastolic BP significantly increased after an initial decline in

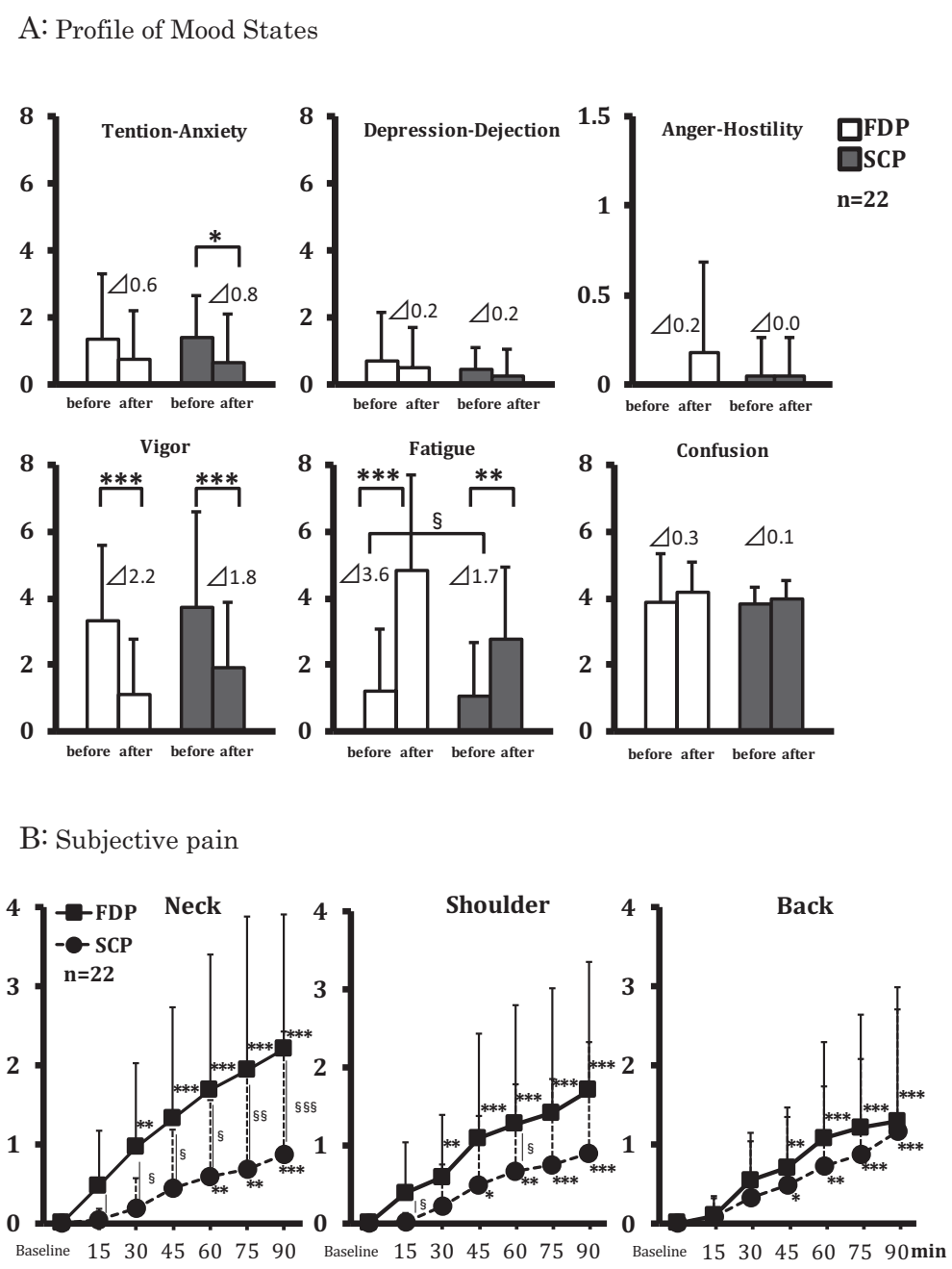

Figure 2. Time courses of psychology responses
Values are mean+SD, FDP; face down positioning, SCP; sitting chair positioning
a: Profile of Mood States, ⊿; difference between before and after, * P<0.05, ** P<0.01, *** P<0.001 before vs. after score, § P<0.05 FDP vs. SCP
b: Subjective pain, * P<0.05, ** P<0.01, *** P<0.001, vs. baseline, § P<0.05, §§ P<0.01, §§§ P<0.001, FDP vs. SCP

both FDP and SCP (P=0.001 and P=0.004, respectively), but there were no significant interactions between position and time course (P=0.279).

Shoulder muscle rigidity

Shoulder muscle rigidity at baseline was 28.9±8.1 points in FDP and 28.7±7.8 points in SCP. Shoulder muscle rigidity in FDP slightly increased from baseline to 90 minutes (ratio 1.035), and a significant difference (one-way ANOVA, P=0.020) was observed, but there was no significant difference in the post-hoc analysis. In SCP, there was a slight increase (ratio 1.091) from baseline to 90 minutes, but no significant difference was observed. There was no interaction between position and time course (P=0.304).

Skin blood flow

Skin blood flow in the shoulder was analyzed in only 17 participants due to malfunction of the measuring equipment. Back skin blood flow was analyzed in all 22 participants. Baseline skin blood flow in the shoulder was 3.3±1.1 ml/

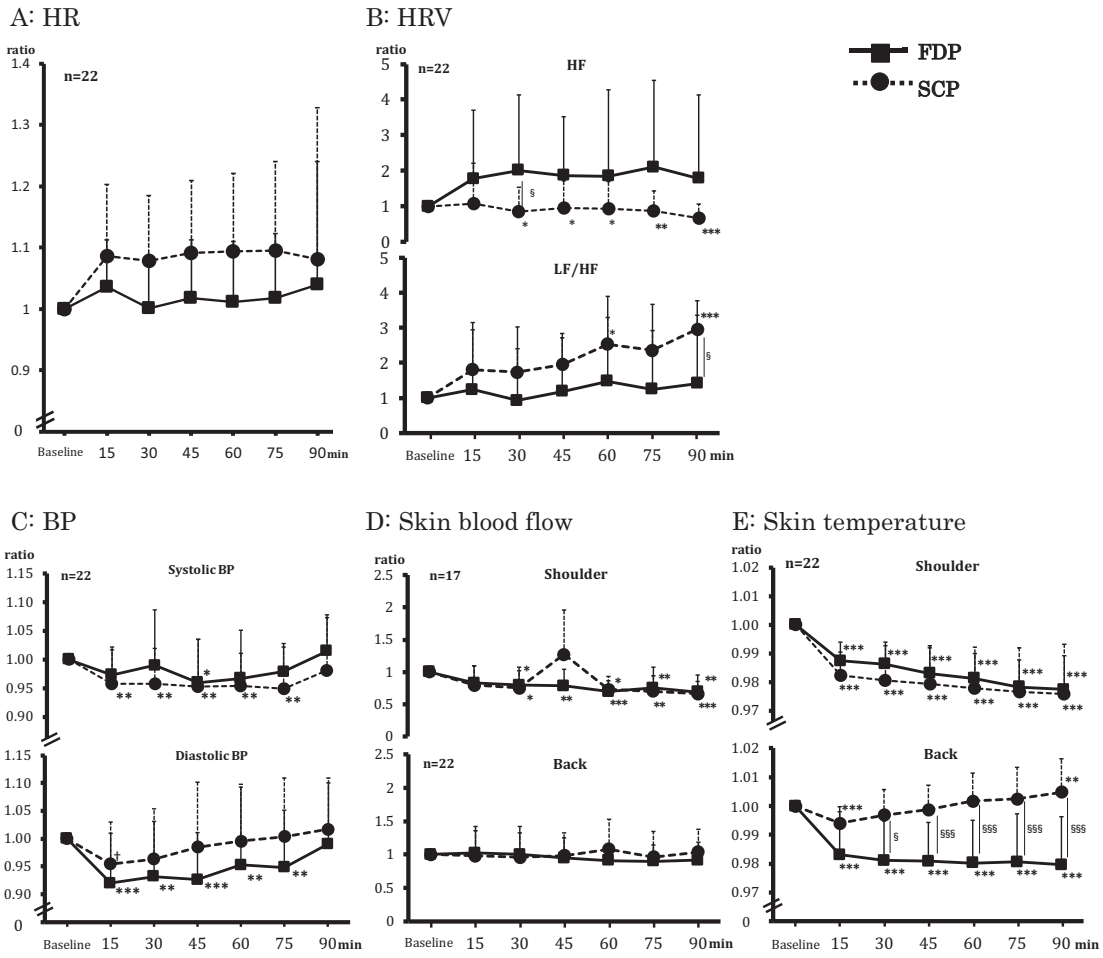

Figure 3. Time courses of physiological responses
Values are mean+SD, FDP; face down positioning, SCP; sitting chair positioning, HF; High Frequency component, HR; Heart Rate, HRV; Heart Rate Variability, LF/HF; component ratio between Low Frequency and HF, BP; Blood Pressure
* P<0.05, ** P<0.01, *** P<0.001, vs. baseline, § P<0.05, §§ P<0.01, §§§ P<0.001, FDP vs. SCP

min/100 g in FDP and 3.0±1.0 ml/min/100 g in SCP, and baseline skin blood flow in the back was 2.6±0.7 ml/min/100 g in FDP and 2.9±1.5 ml/min/100 g in SCP.

Blood flow in the shoulder decreased significantly over time in FDP (P<0.001), but increased at 45 minutes then decreased at 90 minutes in SCP (P<0.001) (**Figure 3**). In addition, a significant interaction was observed between position and time course (P=0.005). However, there was no significant difference between FDP and SCP at any time point. Blood flow in the back did not significantly change over time in either FDP or SCP, and no significant difference between positions was observed. Furthermore, there was no significant interaction between position and time course (P=0.279).

Skin temperature

Baseline skin temperature of the shoulder was 35.5±0.6℃ in FDP and 35.5±0.5℃ in SCP, and baseline skin temperature of the back was 35.2±0.7℃ in FDP and 35.1±0.7℃ in SCP.

Shoulder skin temperature in both FDP and SCP significantly decreased over time (P<0.001 in both), and there was no significant interaction between position and time course (P=0.195) (**Figure 3**). Back skin temperature significantly decreased over time in FDP (P<0.001). In contrast, back skin temperature in SCP initially decreased and then increased, and the change was significant (P<0.001). Furthermore, there was a significant interaction between position and time course (P<0.001). Significant differences were found between positions at each point from 30 to 90 minutes (P=0.012, P<0.001, P<0.001, P<0.001, P<0.001, respectively).

Discussion

In this study, we investigated the influence of maintaining FDP on physiological and psychological responses by comparing FDP with SCP. Psychologically, participants felt more fatigued in FDP than in SCP, and neck and shoulder pain increased markedly over time in FDP. In this study, FDP was based on the posture required after vitrectomy, so participants were instructed to direct their eyes downward and bend forward about 60 degrees, which is the maximum curvature at which the neck was maintained. Therefore, the

burden on the neck and shoulder was strong. Meanwhile, participants in SCP watched a DVD and assumed a posture that required bending the neck about 15 degrees. This posture resulted in a slight but significant increase in pain level. Hansraj et al.[20] reported the force on the adult neck is 10-12 pounds (4-6 kg) at 0 degrees, 27 pounds (12 kg) at 15 degrees forward bend, and 60 pounds (27 kg) at 60 degrees forward bend. In this study, in FDP the forehead was supported by a cushion, so it is unlikely that the force on the neck was 27 kg. However, compared to SCP, FDP was a heavy burden and led to a feeling of psychological fatigue.

We further investigated the physiological responses in FDP based on HR, HRV, shoulder muscle rigidity, skin temperature, and skin blood flow. Both FDP and SCP led to a slight increase in HR over time, but there was no significant change and no interaction was observed. We previously reported that maintenance of FDP for 120 minutes in healthy adults caused a significant rise in HR by 7% at 120 minutes compared to baseline. In this study, however, maintaining the posture for 90 minutes did not appear to significantly change HR. In a clinical setting, patients maintain FDP after vitrectomy for about 90 to 120 minutes, and our result suggested that the posture should not exceed 90 minutes.

We found no significant change in HRV over time in FDP. However, compared with SCP, HF, a marker of parasympathetic nerve activity, was high, and LF/HF, a marker of sympathetic nerve activity, was low, and a statistically significant interaction was observed. Okubo et al.[21] reported that sympathetic nervous activity increases and parasympathetic nervous activity decreases in a sitting position in which the neck is not supported, compared with the supine position and with a sitting position in which the back and neck are supported. Therefore, it is likely that that SCP caused a decrease in HF and an increase in LF/HF that did not occur in FDP.

Both FDP and SCP initially decreased BP, but then increased BP by 90 minutes. No interaction was observed. However, in FDP, diastolic BP decreased markedly and was significantly lower than baseline until 15 to 75 minutes. Since peripheral vasoconstriction is dominated by sympathetic nervous activity, it is possible that low LF/HF in FDP caused peripheral vascular dilation and diastolic BP reduction. However, details of this finding need to be investigated further.

Shoulder skin temperature significantly decreased relative to baseline in both FDP and SCP until 15 to 90 minutes. Similarly, shoulder skin blood flow significantly decreased from 30 to 90 minutes. Incidentally, in SCP, the value at 45 minutes was elevated, but the individual variation in values was large and this elevation was not significant. Neither FDP nor SCP allowed shoulder movement for 90 minutes, so skin blood flow decreased and skin temperature, likewise, decreased. In support of these findings, particularly in FDP, there was a slight but significant rise in shoulder muscle rigidity. On the other hand, in the back region, there were conflicting results and significant interaction. In FDP, skin temperature significantly decreased until 90 minutes, but in SCP, skin temperature initially decreased then significantly increased until 90 minutes. Therefore, when patients maintain FDP, it is important to support their shoulder and back regions, which are particularly susceptible to pain. The method of support should be an intervention that raises skin temperature and skin blood flow, e.g. massage, hot compress, stretch etc.

This study has several limitations. Generally, sympathetic nervous activity is activated by pain stimulus[22]. Although there was a tendency for pain and BP and autonomic functions, there were no significant correlations in this study (HF; P=0.153, LF/HF; P=0.151, SBP; P=0.299, DBP; P= 0.217). It is thought that there were few samples and did not lead to such a drastic change. In addition, the pain on FDP in this study was small increase, thus it is possible that it did not become a significant change to sympathetic nerve activity. SCP, which is often done in daily life, was used as a control in order to examine the psychological and physiological influence of FDP. However, since SCP was accompanied by DVD viewing, it induced a cervix tilting posture of about 15 degrees, and the influence of this posture on autonomic nervous activity was observed. Furthermore, since DVD viewing occurred only in SCP, the possibility of an influence of DVD viewing cannot be excluded. Moreover, it is highly probable that changes in fatigue level, muscle rigidity, and psychogenic factors would be observed if the positions were maintained for longer periods of time that more realistically reflected the posture requirements after vitrectomy.

Conclusions

In this study, the influence of FDP on psychological and physiological factors was examined by comparing FDP with SCP. We found that FDP causes significant psychological burdens including an increase of fatigue, and neck and shoulder pain, as well as physiological burdens such as decreased skin temperature and blood flow in the shoulder and back and increased shoulder muscle rigidity. Our results suggest that proactive support for relieving pain and promoting blood flow from the neck to the back region is necessary when maintaining FDP.

Abbreviations

ANOVA: Analysis of variance; BP: Blood Pressure; FDP: Face-Down Positioning; HF: High Frequency component; HR: Heart Rate; HRV: Heart Rate Variability; LF: Low Frequency component; LF/HF: component ratio between LF and HF; POMS: Profile of Mood States; SCP: Sitting Chair Positioning; VAS: Visual Analog Scale

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Availability of data and materials

The datasets analyzed in this study are not publicly available due to a privacy policy but are available from the corresponding author on reasonable request.

Authors' contributions

CF conceived and designed the study, performed the experiments and the statistical analysis, and drafted the manuscript. TN helped to carry out the experiments. JO helped to perform the data analysis. JO, MA, NK, and KN revised the manuscript critically. All authors have given their final approval.

Ethics approval and consent to participate

Participants provided written informed consent to participate in this study after receiving a detailed explanation regarding the purpose, method, freedom of participation and interruption, maintenance of privacy, and risks involved with participation. The experimental procedures of the study were conducted according to the declaration of Helsinki and were approved by the ethical Committee of Department of Medicine, Saga University (approval number 26-34), Saga, Japan.

Consent for publication

Not applicable.

Conflicts of Interest

The authors declare that they have no competing interests.

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