Journal of the World Federation of Orthodontists 5 (2016) 135–139

Contents lists available at ScienceDirect

Journal of the World Federation of Orthodontists

journal homepage: www.jwfo.org

Research

Work-related cardiovascular stress in orthodontists: A pilot project

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ARTICLE INFO

Article history:
Received 2 February 2016
Received in revised form
19 April 2016
Accepted 3 December 2016

Keywords:
Cardiovascular system of orthodontists
Orthodontic-related stressors
Working time

ABSTRACT

Background: Contemporary orthodontics involves many potentially hazardous factors, including psychological stress with proven undesirable sequelae. The purpose of this study was to gain more insight into cardiocirculatory dynamics in orthodontists during work time and specifically to investigate the potential hazard of a series of orthodontic-related stressors.
Material and methods: The study population consisted of 10 orthodontists (five men and five women, aged 32–65; mean 57 ± 12). A 24-hour automatic device was fitted to each orthodontist to monitor blood pressure and heart rate. The parameter used for statistical analysis was myocardial oxygen consumption (MVO2) as the product of heart rate and systolic blood pressure (double product).
Results: The mean MVO2 percent increase in the entire population of orthodontists during the working day was 25.5 ± 14.1 with a range of 0% to 73%. The mean MVO2 percent increase during operative performances was 29.0 ± 14.1 versus 21.2 ± 13.3 during nonoperative performances; the difference was statistically significant ($F = 11.7$; $P < 0.01$). The mean MVO2 percent increase in the presence of parents was 28.5 ± 15.2 versus 22.6 ± 12.4 in the absence of parents; the difference was statistically significant ($F = 5.4$; $P < 0.05$). A statistically significant relationship was found between single values of MVO2 percent increases during performances and the degree of patient cooperation ($F = 9.4$; $r = 0.27$; $P < 0.01$). No statistically significant relationship ($F = 1.9$) was found between single values of MVO2 percent increases during performances and single values of subjective stress experienced by each orthodontist during each performance.
Conclusions: Routine practice affects the cardiovascular system of orthodontists during the working day. Lack of patient cooperation and psychological pressure from parents in the dental office may have a negative impact on the degree of circulatory dynamics.

1. Introduction

Dentistry is usually considered a stressful profession. Almost one-quarter of the dentists who chose to leave the profession reported stress or burnout as their main reason for changing careers [1,2]. High work stress has been associated with an increased risk of cardiovascular diseases [3–5]. The detrimental effects of work stress are partially mediated through increased heart rate reactivity, increased systolic blood pressure, and lower 24-hour vagal tone. These three characteristics of high work stress are all associated with an increased cardiac disease risk [6–8].

In 1977, Cutright et al. [9] conducted an epidemiological study on 856 dentists, demonstrating a twofold higher prevalence of hypertension with respect to the general population. Gortzak et al. [10] investigated blood pressure and heart rate fluctuations in 26 dentists during their daily activities, showing that both blood pressure and heart rate were significantly higher during work than during leisure activities, whereas no significant differences were found between these periods in a control group.

Exaggerated cardiovascular stress during routine dental practice has been widely reported. In 1983, Moore and Ligget [11] documented major heart rate increases in a population of 26 dentists during 78 local anesthesia procedures; approximately half of them reported being affected by patient anxiety during anesthesia, and all of them had significantly higher heart rate values than dentists not reporting being affected by patient anxiety. The major role of patient anxiety in determining high cardiovascular stress in

All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.

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2212-4438/$ – see front matter © 2017 World Federation of Orthodontists.
http://dx.doi.org/10.1016/j.ejwf.2016.12.003

dentists was pointed out in two studies conducted in 1989 and 1999. Borea et al. [12] reported the results from six dentists who performed 12 dental extractions each on six patients classified as anxious and six patients as nonanxious. Their findings showed that the cardiovascular reactions in dentists were statistically stronger when operating on anxious patients, and that patient anxiety was more stressful for their circulatory dynamics with respect to the difficulty of dental extractions. Similar results were obtained a decade later by Brand [13], who reported high heart rate and blood pressure variations induced by patient anxiety in a group of dentists during local anesthesia administration or dental scaling.

Working conditions were also reported to be important in determining high cardiovascular stress in dentists. In 1990 and 1991, Borea et al. [14,15] conducted two studies in which exaggerated pressure and forearm circulatory response were observed when dentists operated in incorrect working conditions. Subsequently, Montebugnoli et al. [16], studying a group of dentists operating with two differently designed dental units, demonstrated that cardiovascular stress is conditioned by the different arrangement of dental instrumentation.

Although occupational stress in general dentistry has been widely investigated, occupational stress in orthodontics has not been so well researched [17]. Contemporary orthodontics involves many potentially hazardous factors related to the general setting of the practice, including psychological stress with proven undesirable sequelae [18].

Studies describing the stressful aspects of dentistry included a number of specialists responding to a survey, but none reported a separate analysis of the specialists' responses [19,20]. In 2003, Roth et al [21]. were the first to evaluate occupational stress in orthodontics, conducting a survey on 355 orthodontists that included 67 potential stressors. The results disclosed 24 items with a moderate/high mean severity score [22]: some of them were similar in orthodontics and dentistry [1,20,23], whereas others were scored as highly stressful in the orthodontic population without any frequent appearance in dental studies. In 2011, Pirillo et al. [24] conducted an epidemiological study to evaluate the incidence of burnout syndrome in a population of 366 dentists, 189 of them orthodontists. The results showed that although the incidence of burnout was lower among orthodontists than general dentists, 32% of orthodontists reported moderate/high scores for emotional exhaustion, 40% for depersonalization and 26% for personal accomplishment [24].

The limit of all these studies is that all data are from epidemiological surveys conducted by questionnaires to evaluate the psychological stress experienced by orthodontists during routine practice. There is a lack in the literature of data from clinical studies addressing the hemodynamic changes that may occur in the orthodontic setting.

The purpose of this prospective study was to gain more insight into cardiocirculatory dynamics in the orthodontists during work time and specifically to investigate the potential hazard of a series of orthodontic-related stressors.

2. Materials and methods

The study population consisted of 10 orthodontists (five men and five women aged 32–65; mean 57 ± 12 years). All subjects were healthy and no subjects smoked. The minimum sample size was determined "a priori" by assessing the power of our tests using $\pi = 0.80$ as a standard for adequacy, which implies a four-to-one trade-off between β-risk (0.20) and α-risk (0.05). The sample size was 10, resulting from powering the study to detect a minimum clinically significant difference in MVO2 of 1.5 mL/min using $\alpha = 0.05$, a power of 80%, and a hypothesized within-group sigma of 1.5 mL/min obtained from previous studies [25]. The adequacy of a so apparently small size is also legitimized by the fact that the study was designed as an "intrasubject" comparison that avoids any possible interference due to the between-subject variability when comparing different populations.

An automatic device (Ambulatory blood pressure system 90207; Spacelabs Healthcare Company, Issaquah, WA) was fitted to each orthodontist to monitor blood pressure and heart rate. These parameters were evaluated in each orthodontist while sitting in a comfortable position at the beginning of the working day (basal values) and every 10 minutes during each performance; performances were considered only if lasting at least 10 minutes and at least 5 minutes apart.

The first six operative and nonoperative performances were considered for each orthodontist. The following operative performances were considered: banding, debonding, impressions, interproximal stripping, arch ligation, application of palatal expander, orthodontic chain, lip bumper, and retainer. The following nonoperative performances were considered: examinations and checkups.

The presence/absence of parents inside the dental office during each performance (operative and nonoperative) was regulated by a randomization list.

The ethical aspects of the clinical study have been considered; in particular, all subjects and all parents were assured about the absence of any interference of the clinical protocol regarding the orthodontic treatment. The work was approved by the ethical local committee and informed consent was obtained from all subjects and parents.

The parameter used for statistical analysis was myocardial oxygen consumption (MVO2), as the product of heart rate, and systolic blood pressure (double product calculated by the product of heart rate and systolic blood pressure/1000) used as an estimate of myocardial (heart muscle) work and proportional to myocardial oxygen consumption; percent increase in MVO2 with respect to basal values represents the increase in myocardial work during stress [25–27].

The results have been expressed as percent increases in MVO2 in each orthodontist considering the following: mean (±SD) MVO2 increase throughout the working day with respect to basal values, and mean (±SD) MVO2 increase during each performance with respect to basal values.

Among the variables affecting cardiovascular stress, the following were considered:

- type of performance: operative vs nonoperative;
- presence vs absence of parents;
- patient cooperation evaluated on a visual analog scale (VAS) scale (0 = patient extremely cooperative; 10 = patient totally uncooperative) by all orthodontists at the end of each performance;
- VAS scale (0 = no subjective stress; 10 = extremely high subjective stress) at the end of each performance.

Data showed a normal distribution with a standardized skewness of 1.23 and standardized kurtosis of 1.35, so the following parametric tests were used: multifactor ANOVA to evaluate the presence of any significant difference in mean MVO2 percent increase during operative and nonoperative performance, in the presence or absence of parents inside the dental office, and in collaborative and noncooperative patients (cutoff = 5 on VAS); age and gender were introduced to the model as covariates.

Linear regression to disclose a relationship between single percent increases in MVO2 and single values of patient cooperation or subjective stress experienced by each orthodontist.

3. Results

The mean basal value of MVO2 in the entire population was 8.4 ± 1.6 mL/min. The mean MVO2 percent increase in the entire population during the working day was 25.5 ± 14.1 with a range of 0% to 73%. The mean MVO2 percent increase during operative performances was 29.0 ± 14.1 versus 21.2 ± 13.3 during nonoperative performances; the difference was statistically significant ($F = 11.7$; $P < 0.01$) (Fig. 1). The mean MVO2 percent increase in the presence of parents was 28.5 ± 15.2 versus 22.6 ± 12.4 in the absence of parents; the difference was statistically significant ($F = 5.4$; $P < 0.05$) (Fig. 2). The results from multifactor ANOVA showed that the forcing of age and gender into the models did not affect the statistical significance.

A statistically significant relationship was found between single values of MVO2 percent increases during performances and the degree of patient cooperation as reported by each orthodontist at the end of each performance ($F = 9.4$; $r = 0.27$; $P < 0.01$) (Fig. 3).

Considering a cutoff of 5 mm (VAS scale), the mean MVO2 percent increase in the case of poor patient cooperation (26 performances) was 32.5 ± 18.7 versus 23.5 ± 11.9 in the case of good (94 performances) patient cooperation ($F = 8.9$; $P < 0.01$).

No statistically significant relationship ($F = 1.9$) was found between single values of MVO2 percent increases during performances and single values of subjective stress experienced during each performance.

4. Discussion

This is the first study to document cardiovascular stress in a group of orthodontists during the working day. To quantify cardiovascular stress, we adopted a cardiocirculatory parameter widely used in the literature for this purpose. This parameter relates to myocyte contraction, which is the primary factor determining MVO2. Factors that enhance tension development by the cardiac muscle cells, the rate of tension development, or the number of tension-generating cycles per unit time will increase MVO2. Stressful situations increase MVO2 through an increase in the heart rate, cardiac inotropism, and blood pressure. For example, doubling heart rate approximately doubles MVO2 because ventricular myocytes are generating twice the number of tension cycles per minute. Increasing inotropy also increases MVO2 because the rate of tension development is increased as well as the magnitude of tension, both of which result in increased ATP hydrolysis and oxygen consumption. Increasing afterload, because it increases tension development, also increases MVO2.

Oxygen consumption by the heart can be estimated in humans by measuring venous oxygen saturation that requires catheterization of the coronary sinus and coronary blood flow. Relative changes in MVO2 can be estimated by using an indirect index such as the pressure-rate product. There are different variations of this index, but one method simply multiplies the aortic systolic pressure by the heart rate. The pressure-rate product is based on the observation that MVO2 is closely related to ventricular wall tension and has been widely used as an estimate of myocardial (heart muscle) work and myocardial oxygen consumption [25–27].

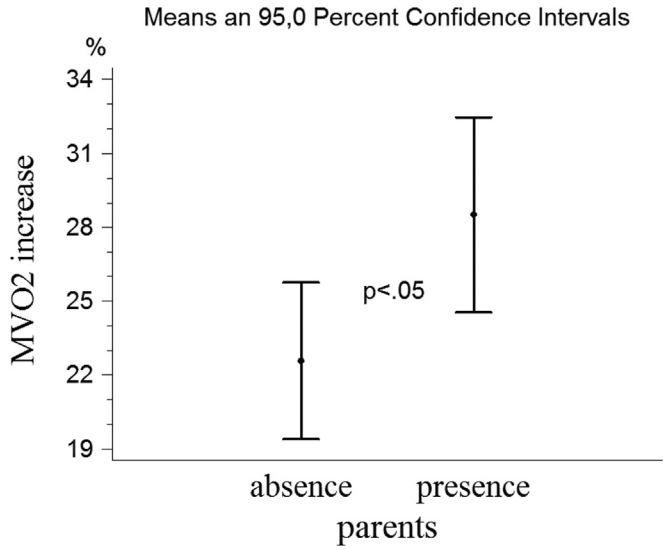

Fig. 2. MVO2 mean (95% confidence intervals) percent increases in orthodontists during interventions in the absence or in presence of parents.

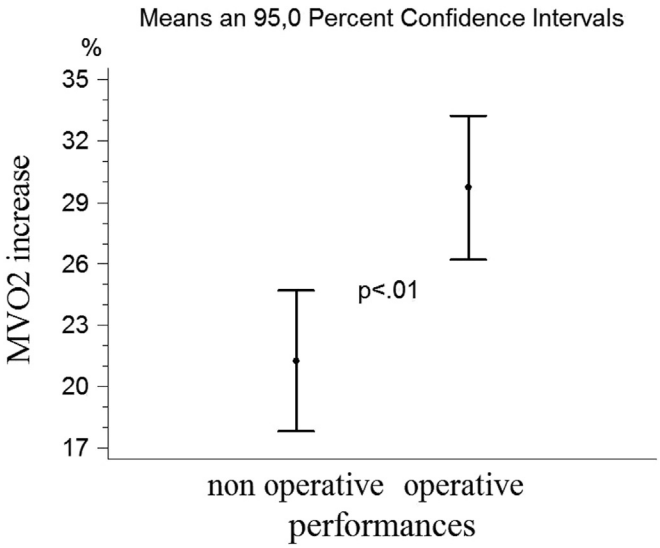

Fig. 1. MVO2 mean (95% confidence intervals) percent increases in orthodontists during nonoperative and operative performances.

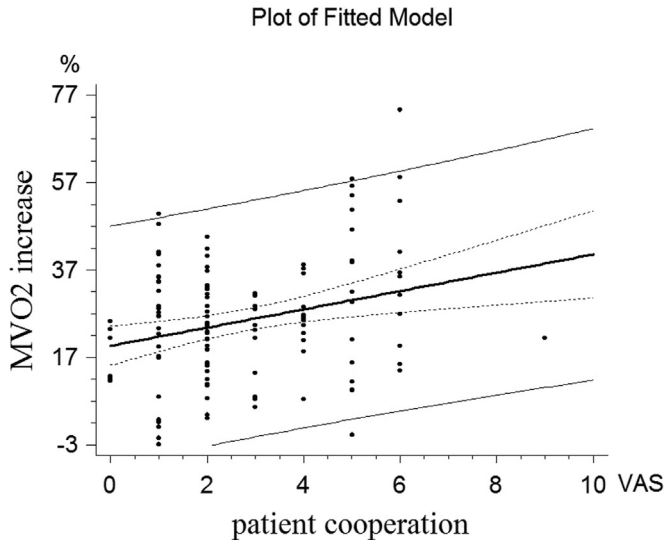

Fig. 3. Relationship between MVO2 increases in orthodontists during performances and degree of patient cooperation (values range from 0 = cooperative to 10 = uncooperative).

Our results showed that during routine practice, orthodontists may experience considerable increases in their circulatory dynamics: an overall mean 25% increase in MVO2 throughout the working day, with MVO2 peaks of even 73%, can be considered significant cardiovascular stress. As expected, the type of performance, operative versus nonoperative, was the most important item responsible for cardiovascular stress in all orthodontists, although a 21% mean increase in MVO2 was also reached during routine controls.

The study design does not establish the real meaning of such MVO2 increases because of the lack of other subjects and controls. However, the data can be compared with those obtained in previous studies using the same circulatory parameter.

A mean MVO2 increase of approximately 20% (i.e., slightly less than that obtained in the present study) was recorded in a population of general dentists performing amalgam restorations [28]. Again, the performance of a dental extraction, another stressful procedure, by general dentists determined a mean MVO2 increase of approximately 31%, a value not far from that found in the present study [12]. It also must be mentioned that 31% is the mean increase reported in healthy subjects undergoing dental extractions [22].

Although the real meaning of circulatory stress in our orthodontists is a matter of speculation, the intrasubject analysis performed in the present study allowed us to quantify the influence of a series of orthodontic-related stressful items.

A major stressful aspect of orthodontic practice in the present study is patient cooperation. The significant relationship between single MVO2 increases in orthodontists and VAS values related to patient compliance suggests that higher increases in circulatory dynamics may be reached in case of poor compliance. When 50% of a VAS is chosen as a cutoff value to divide patients into cooperative or uncooperative, an MVO2 mean increase of 32% was reached in orthodontists operating on uncooperative patients compared with a mean increase of 23% in performances conducted on cooperative patients. The perception of patient anxiety by dentists is a well-known topic [20,29–31], and dentists express widely varying levels of cardiovascular stress when operating on anxious compared with nonanxious patients [12]. Our results reinforce those of the epidemiological survey by Roth [21] on 355 orthodontists, reporting that the treatment of uncooperative patients was one of the most stressful items related to orthodontic practice.

The relevance of psychological pressure on the cardiovascular dynamics of orthodontists is emphasized in the present study by the significant negative effect of the presence of parents in the dental setting. A mean MVO2 increase of 28% was observed when orthodontists operated in the presence of family members compared with 22% when parents waited outside the office. If we consider MVO2 increases in orthodontists when operating on uncooperative patients in the presence of parents, we obtain a mean value of 35%, a much higher rate than that obtained in the same orthodontists when operating on cooperative patients in the absence of parents.

The results of the present study do not determine whether cardiovascular stress during routine practice can expose orthodontists to a similar risk of developing cardiovascular diseases as general dentists, and no data are currently available on the relative cardiovascular risk of dentists practising orthodontics. However, orthodontists should be aware that routine practice can be stressful for their cardiovascular system and that patient anxiety and parental pressure are items that can significantly influence their circulatory dynamics.

The issue is exacerbated by the fact that the present study demonstrated no significant relationship between objective circulatory stress and the subjective stress experienced by each operator. In fact, several performances determining high circulatory dynamics in some orthodontists were experienced as low stress situations and vice versa. The lack of a relationship between subjective stress and cardiovascular stress is a well-known issue [32,33] and unawareness of work-related circulatory stress can lead orthodontists to underestimate the problem and fail to apply preventive measures to better manage stressful situations.

5. Conclusion

Routine orthodontics affects the cardiovascular system of orthodontists during routine practice. Lack of patient cooperation and psychological pressure from parents inside the dental office may have a negative impact on the degree of circulatory dynamics.

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