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# Comparison of subjective and objective measures of office workers' sedentary time

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ABSTRACT

Sedentary behavior is an independent and prominent risk factor for chronic disease. Occupational sitting is likely to be the largest determinant of overall daily sitting time. Gathering accurate data on sedentary behaviors is essential to determine prevalence and effectiveness of interventions to reduce sedentary time. The purpose of this research was to determine whether self-reported sedentary time assessed by the Paffenbarger Physical Activity Questionnaire (PPAQ) and the Occupational Sitting and Physical Activity Questionnaire (OSPAQ) was related to objectively assessed sedentary time by the activPAL3 activity monitor. In the spring of 2015, 44 women employed full-time at Slippery Rock University participated in this study. Participants were predominantly Caucasian (95%), middle-aged (48 ± 10 years), and had an average BMI of 30.5 ± 8.2. A positive, weak correlation was found in sedentary time between the PPAQ (14.65 ± 2.77 h) and the activPAL3 (17.71 ± 1.46 h) over a 24 hour day (r = 0.253; $p$ = 0.098; n = 44). Thirty-nine of the 44 participants significantly underestimated their sedentary time as compared to the activPAL3 (3.06 ± 2.76 h; $p$ = 0.001). A positive, weak correlation was also found in sedentary time between the OSPAQ (5.96 ± 1.11 h) and the activPAL3 (5.69 ± 1.06 h) during the 8.5 hour work day (r = 0.100; $p$ = 0.518; n = 44). Future studies examining sedentary behaviors should use caution when only considering the use of subjective recall surveys. This is especially true when self-reported behaviors are used to inform health promotion programs and create universal recommendations aimed to reduce sedentary time.

## 1. Introduction

Scientific evidence supports that regular exercise and physical activity (PA can improve health and reduce the risk of chronic disease and premature mortality (Bauer et al., 2014; Center for Disease Control and Prevention, 2014; Thompson, 2010). Sedentary behavior has been identified as an independent and prominent risk factor for chronic disease, even for those who meet the guidelines for exercise and PA (Cooley and Pederson, 2013; Ellingson et al., 2013; Peterson et al., 2014). The term "sedentary" can be defined based on metabolic cost of activity or inactivity that requires low levels of energy expenditure (≤ 1.5 METS), or as a distinct group of behaviors characterized by time spent sitting, lying, or reclined during waking hours (Sedentary Behaviour Research Network, 2012). Evidence suggests that a large volume of sedentary tome increases the risk of chronic disease and all-cause mortality, after adjusting for time spent in moderate to vigorous physical activity (World Health Organization, 2014; Katzmarzyk, 2014; Pate et al., 1995; Thompson, 2010).

Sitting time can be monitored during the work hours as part of a comprehensive assessment of total daily sedentary time. Occupational sitting is likely to be the largest determinant of overall daily sitting time (Ryan et al., 2011; Thorp et al., 2011). Previous studies report office workers were sedentary for an average range of 66%–82% of work hours (Ryan et al., 2011; Bird et al., 2015; Castillo-Retamal and Hinckson, 2011; Parry and Straker, 2013; Ryde et al., 2013; Thorp et al., 2012; Toomingas et al., 2012). Large amounts of occupational sitting are perpetuated by screen time, inactive commutes, and the use of labor-saving information and communication devices, which has led to the decrease of daily occupational energy expenditure, by approximately 100 kcal/day, over the last five decades (Church et al., 2011; Owen et al., 2011).

The activPAL3 has been identified as a valid measure of posture, motion, and sedentary behavior in adults, as it offers a superior accuracy compared to many self-report measures (Thorp et al., 2012; Oliver et al., 2010; Grant et al., 2006; Kozey-Keadle et al., 2012; Hart et al., 2011). Similarly, the Paffenbarger Physical Activity Questionnaire (PPAQ) and Occupational Sitting and Physical Activity Questionnaire (OSPAQ) have been reported to be valid and reliable to assess sedentary

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behavior in similar adult populations (Paffenbarger et al., 1993; Ainsworth et al., 1993; Chau et al., 2012; Paffenbarger et al., 1978). Self-report measures that show convergence when conducted simultaneously with objective measures such as the activPAL3 may provide researchers with less costly options to further study sedentary behavior (Hart et al., 2011). Accordingly, questionnaires that measure domain-specific sitting time may be acceptable to estimate population based associations between sitting time and subsequent health outcomes (Marshall et al., 2010). Thus, there continues to be a need to compare questionnaires that assess sedentary time to a valid criterion measure (Kozey-Keadle et al., 2012).

Therefore, gathering accurate data on sedentary behaviors in and out of the workplace is essential to determine prevalence and effectiveness of interventions to reduce or disrupt sedentary time (Oliver et al., 2010). Given that both subjective and objective instruments capture important aspects of sedentary behavior, utilizing both types of measures seems warranted. Ideally, the instruments chosen should allow for comparison across time and integrate multiple levels of information to provide the greatest contextual understanding associated with sedentary behaviors. The purpose of this research was to determine whether self-reported sedentary time assessed by the PPAQ and OSPAQ was related to objectively assess sedentary time by the activPAL3 activity monitor.

## 2. Methods

### 2.1. Participants

Forty-four women who were at least 18 years of age, employed full-time at a university campus and had a sedentary job description were included in this investigation (Fig. 1). All participants worked a verified schedule of 8:00 am–4:30 pm, Monday–Friday. Participants were predominantly Caucasian (95%), middle-aged (48 ± 10 years), and had an average BMI of 30.5 ± 8.2). Individuals were excluded if they had any disability that would inhibit wearing the activity monitors or participating in physical activity. Participants in this study were the same group described in a previously published study that examined the effect of a workplace intervention to reduce sedentary time (Urda et al., 2016). This study was approved by the University Institutional Review Board, and all participants provided written informed consent.

### 2.2. Design and procedures

At bassline, all participants completed the PPAQ and OSPAQ. An activPAL3 activity monitor (v7.2.32PAL Technologies Ltd., Glasgow, UK) was placed on each participant and detailed instructions on proper use and placement were provided. Participants continuously wore the activPAL3 activity monitor for seven consecutive days and were asked to maintain their current level of physical activity. At the end of the seven days, participants completed the PPAQ and OSPAQ again and returned their activPAL3 activity monitor.

### 2.3. Instrumentation

Height was measured using a wall-mounted stadiometer to the nearest 0.25 in. Weight was measured using a calibrated balance-beam scale to the nearest 0.25 lb. Body mass index (BMI) was calculated as body weight (kg) divided by height squared ($m^2$). The activPAL3 activity monitor is a validated light-weight, credit card sized uniaxial piezoresistive activity monitor that measures movement in three planes: sitting, standing, and stepping activities, as the activPAL3 incorporates both accelerometer and inclinometer functions (Grant et al., 2006; Kozey-Keadle et al., 2012; Edwardson et al., 2016). The monitor was worn on the midline anterior aspect of the thigh, covered by a waterproof finger cot and adhered to the skin with the non-allergenic adhesive tape. The activPAL3 can be worn for a period up to 10 consecutive days. Proprietary software was used to summarize data as time spent sitting/lying in total hour/week and while at work (8.5 h).

The PPAQ (Paffenbarger et al., 1993; Ainsworth et al., 1993) was utilized to assess subjective sedentary time during the previous seven days. The questions elicit duration for vigorous, moderate, and light PA, as well as sedentary time, which is considered any time spent sitting and sleeping/reclined. Subjective estimates of the amount of time over the past week in hours/day on a weekday and weekend day were self-reported for vigorous, moderate, and light PA, and total sedentary time, or sitting and lying/reclined time over a 24-hour period. Sedentary time was reported for a typical weekday and weekend day.

The OSPAQ (Chau et al., 2012) was utilized to collect subjective sedentary time for participants while at work (8.5 h) over the previous seven days. The questions elicit percentages of time spent sitting, standing, walking, and in physically demanding tasks or hard labor throughout a typical workday. Travel to and from work and leisure time while at work were excluded. Hours per workday spent sitting was determined using the equation presented by Chau et al. (2012). Data were recorded in hours/week and hours/day.

### 2.4. Statistical analysis

Statistical analysis was conducted utilizing SPSS software (IBM, version 19). The significance level was set at 0.05 for all data analyses. A Pearson Product Correlation was utilized to examine if a relationship existed between sedentary time subjectively assessed from the PPAQ and objectively measured by the activPAL3 in hours per week over 24 h. A Pearson Product Correlation was also utilized to examine the relationship between sedentary time subjectively assessed from the OSPAQ and objectively measured by the activPAL3 during work hours. Additionally, error scores were calculated to assess the difference in agreement between the objective (activPAL3) and subjective (OSPAQ and PPAQ) assessments, and a Bland-Altman analysis was conducted to explore systematic bias.

## 3. Results

A positive, weak, non-significant correlation was found in sedentary time between the PPAQ (14.65 ± 2.77 h) and the activPAL3 (17.71 ± 1.46 h) over a 24-hour day ($r = 0.253$; $p = 0.098$; $n = 44$). Further, variation in self-reported sedentary time only explains 6% ($r^2 = 0.064$) of the variation in actual sedentary time. Self-reported sedentary time was systematically underestimated as determined by the Bland-Altman analysis. Thirty-nine of the 44 participants significantly underestimated their sedentary time as compared to the activPAL3 (3.06 ± 2.76 h; $p = 0.001$), with 19 participants having a difference > 3 h during a 24-hour period. Fig. 2 represents the error included in the self-reported sedentary time estimated by the PPAQ.

A positive, weak, non-significant correlation was also found in sedentary time between the OSPAQ (5.96 ± 1.11 h) and the activPAL3 (5.69 ± 1.06 h) during the 8.5 hour work day ($r = 0.100$; $p = 0.518$; $n = 44$). The mean error of the estimation was approximately one-quarter of an hour (0.27 ± 1.46), with 24 of the participants overestimating and 18 underestimating their sedentary time while at work. Nineteen of the 44 participants estimated more than an hour (1.1–4.2 h) difference between their sedentary time during their workday and what was objectively measured. Error included in self-reported sedentary time estimated by the OSPAQ is illustrated in Fig. 3. There was no systematic bias ($p = 0.743$) in the OSPAQ subjective assessment relative to the activPAL3 objective assessment as demonstrated by the Bland-Altman analysis (Fig. 4).

## 4. Discussion

Due to previously established criterion validity of the subjective and objective measures used in the present study, convergence was

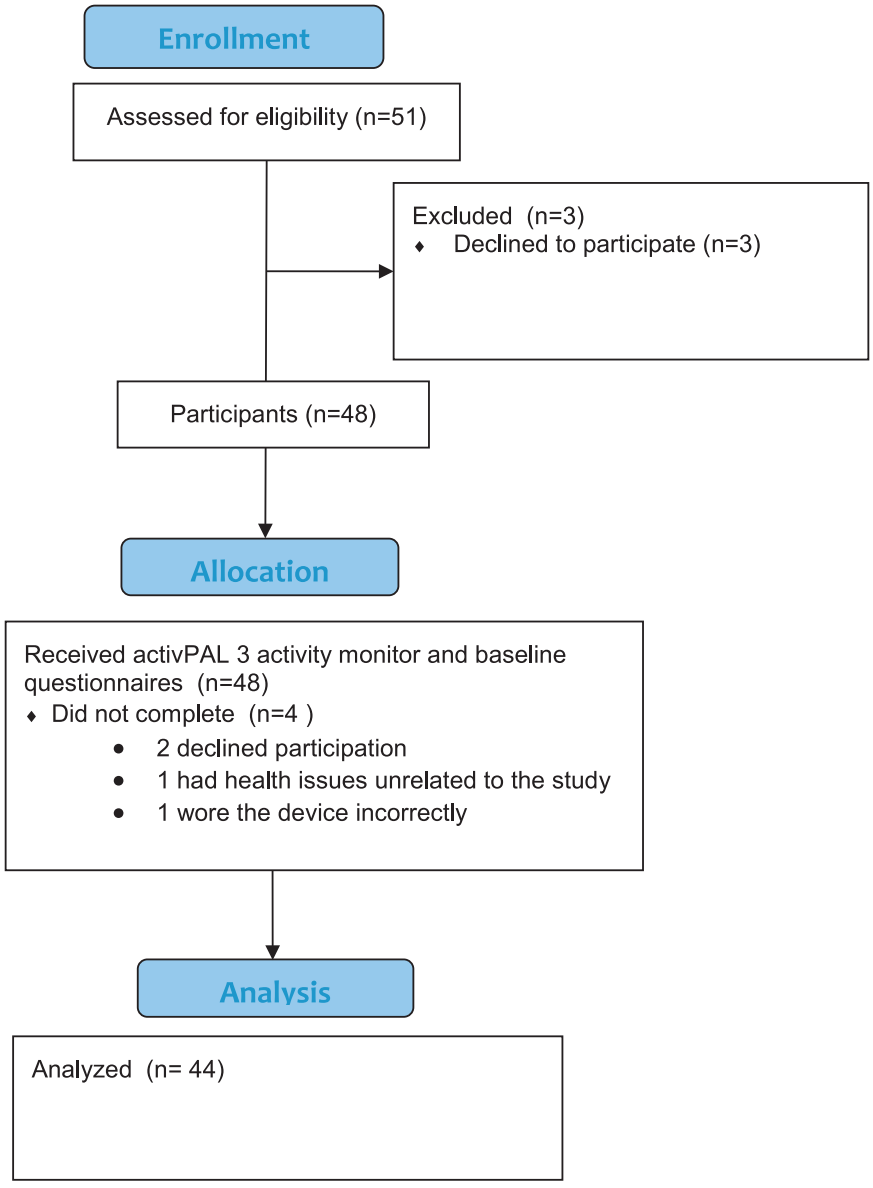


**Fig. 1.** Participant flow chart.

expected between sedentary time by the PPAQ and OSPAQ and sedentary time measured by the activPAL3 (Chau et al., 2012; Simpson et al., 2015; Pederson et al., 2016). The PPAQ and OSPAQ have independently been reported to be valid with high test-retest reliability (Ainsworth et al., 1993; Chau et al., 2012; Simpson et al., 2015; Wasburn et al., 1987), thus reasonable choices to assess sedentary behaviors. However, in the present study, the PPAQ and OSPAQ did not show convergence with the activPAL3 for time spent sedentary in concurrent time periods.

These findings are similar to many previous investigations that have reported subjective measures to be less sensitive and include recall bias in relation to changes in behavior variables, such as sedentary time (Castillo-Retamal and Hinckson, 2011; Hart et al., 2011; Simpson et al., 2015; Kozey-Keadle et al., 2011; Clark et al., 2011; Atkin et al., 2012). In the present study, self-reported sedentary time was systematically underestimated as measured by the PPAQ. Approximately 43% of participants self-reported a difference $>$ 3 h determined by the PPAQ, as compared to activPAL3. Additionally, for purposes of this study, sleep time was included as part of self-reported sedentary time outside of work hours, given that it is included as part of self-reported sedentary time on the PPAQ. Other researchers have chosen to eliminate sleep when evaluating total sedentary time; therefore, the results of the present study cannot be compared to their findings (Matthews et al., 2008). On the other hand, sedentary time measured by the OSPAQ showed no proportional bias found after a Bland-Altman analysis, which could be potentially misleading considering the average estimation was approximately an hour different from objectively measured sitting time, during an 8.5 workday. It is important to note that great variance was found with the OSPAQ, as half of the participants underestimated sitting time at work, while the other half of participants overestimated sitting time at work. These findings are in contrast to Chau et al. (2012), and Jancy et al. (2014), who concluded the OSPAQ has a strong relationship with the activPAL3 with high reliability and moderate validity for sitting time at work. However, similar to the findings of this study, Pederson et al. (2016) reported the OSPAQ to have poor reliability, and cautioned making any recommendations based on its data alone. Atkin et al. (2012) report single-item questions that group all domains of sedentary time, as found with the PPAQ and OSPAQ, frequently underestimate sedentary behavior.

It is essential and timely to have high quality methods for measuring sedentary behavior. The measurement of sedentary behavior remains relatively underdeveloped, yet both objective and subjective measures

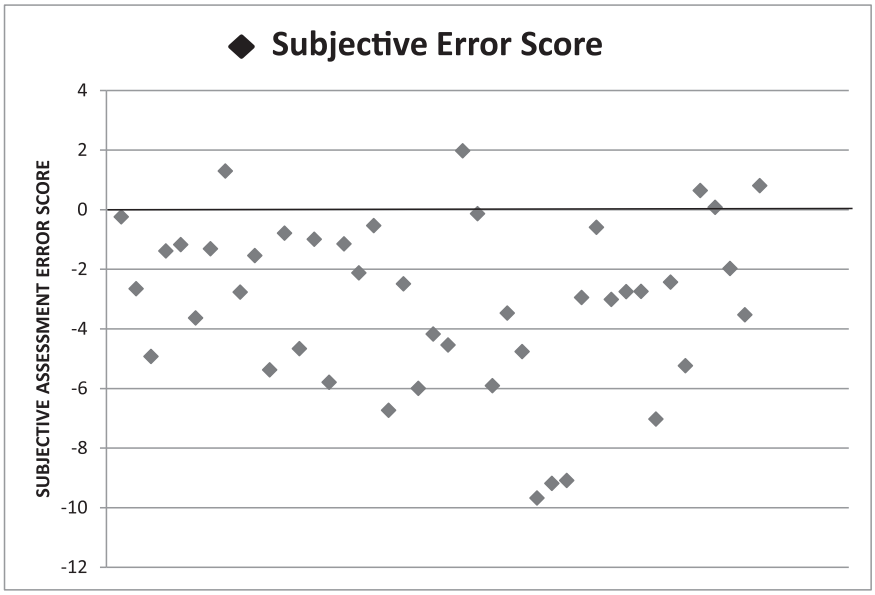


**Fig. 2.** Error in subjective recall of sedentary time over a 24 hour period (PPAQ) with objective measure (activPAL3) set at zero and the error displayed as the difference between the objective and subjective assessments.

show good potential and warrant further testing (Atkin et al., 2012). Objective measures, such as activity monitors, are commonly used as the criterion standard for sedentary behavior. At the same time, these measures are often costly, require more participant time and effort, are only possible with smaller sample sizes, and have no consensus regarding data processing. Self-report questionnaires are commonly used as a method to capturing sedentary behavior. Self-report questionnaires are inexpensive, relatively easy to administer to large groups, can be domain specific, and do not often take a lot of time or effort to complete. On the other hand, there are inherent issues with the validity of self-report, as a resulting misclassification of behaviors, misunderstanding of questions, and recall bias influenced by cultural norms or socially desired behavior can result (Castillo-Retamal and Hinckson, 2011; Church et al., 2011; Simpson et al., 2015; Atkin et al., 2012).

Ultimately, future investigations that examine similar populations to the one used in the present study should be cautioned not to rely on the PPAQ or OSPAQ data as a sole dependent variable. The trend of underestimating self-reported sedentary time may also be a result of increased awareness of sedentary time, and the participants' desire to present themselves in a positive light, enhancing self-esteem and aligning with socially acceptable norms (Pederson et al., 2016; Chastin et al., 2014; Healy et al., 2011). While the most current definition of sedentary behavior includes both energy expenditure and postural elements, an ideal scenario has been reported to be a combined use of supplemental objective measures to help improve some challenges characteristics to subjective measures (Hart et al., 2011; Pederson et al., 2016; Chastin et al., 2014; Healy et al., 2011).

### 4.1. Study limitations and strengths

There are several limitations that must be considered when interpreting the findings of the present study. The participants were a convenience sample, which leaves the potential for selection bias, and limited generalizability of the results to other sedentary populations. Further, the modest sample size included in this study may limit generalization of the findings to a larger population. Additionally, the participants could have limited demographic variability as they were all faculty and staff at a rural university. The principle strengths of the current study were that work hours and out-of-work hours were evaluated separately so that specific behaviors could be analyzed individually. Participants were monitored for 24 h so that sleep could be evaluated as a potential compensatory behavior, and there was less likelihood that participants would forget to replace the accelerometer if removed. As seen with the participants in this study, high compliance is associated with continuous activity monitor wear protocols. Further, verbal, visual, and written activity monitor instructions were provided to the participants. The simultaneous evaluation of accelerometer and

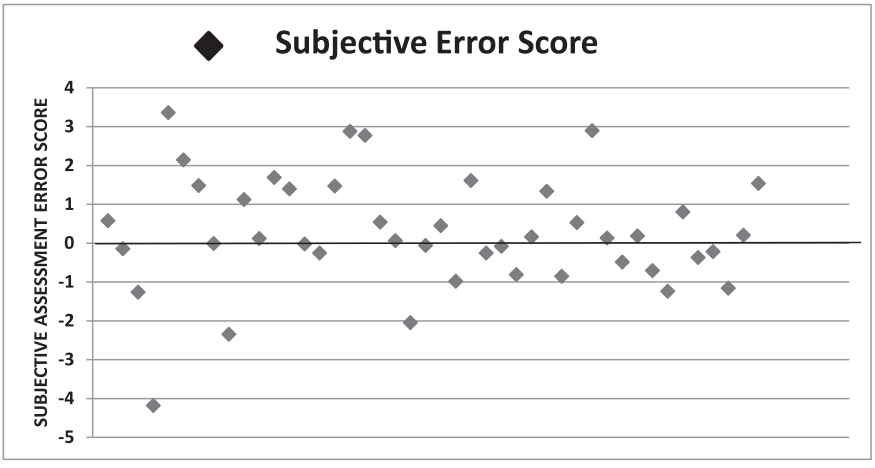


**Fig. 3.** Error in subjective recall of sedentary time at work (OSPAQ) with objective measure (activPAL3) set at zero and the error displayed as the difference between the objective and subjective assessments.

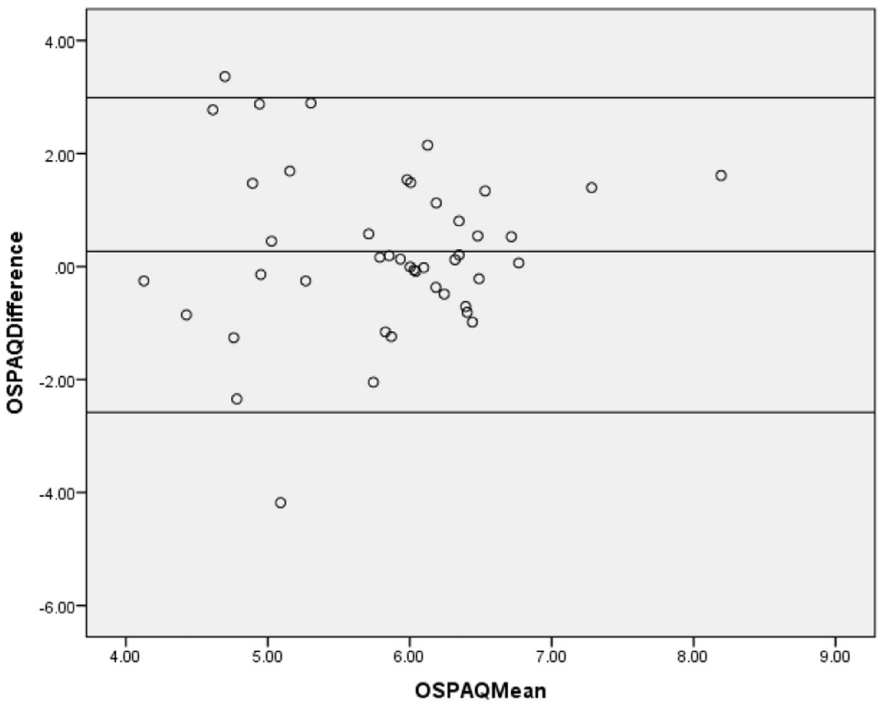


**Fig. 4.** Bland-Altman plot of agreement between OSPAQ and activPAL3.

subjective recall allowed for direct comparison of the two and assessment of the subjective measures against the objective standard.

## 5. Conclusion

Based on the results of this study and the existing literature, future studies examining sedentary behaviors throughout the day should use caution when only considering the use of subjective recall surveys such as the PPAQ and OSPAQ. This is especially true when self-reported behaviors are used to inform health promotion programs and create universal recommendations aimed to reduce sedentary time at the workplace. Further, it is recommended that subjects understand the differences between sedentary time and physical activity, as well as the specific domains of sedentary time, to better recall their behaviors when completing a questionnaire.

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## Disclaimer

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## Conflict of interest

The authors do not have any conflicts of interest or professional relationships with companies or manufacturers who would benefit from the results of this study.

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