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ORIGINAL ARTICLE

Influence of gender, BMI and Hispanic ethnicity on physical activity in children

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Abstract

Objective. The purpose of this study was to examine the association between overweight status and physical activity (PA) among gender and ethnic (Hispanic vs. non-Hispanic) sub-groups in elementary school-age children. **Methods.** PA was assessed over five days using the Actigraph accelerometer in 169 fourth grade students (mean age 9.4 years; 50% female; 63% Hispanic; and 43% overweight, defined as body mass index, BMI $\geq 85^{\text{th}}$ percentile for age and gender) from four elementary schools in Los Angeles County, California. **Results.** In the total sample, boys and normal weight students had higher levels of total PA (counts per minute, cpm; $p < 0.05$). Boys spent less time in sedentary PA ($p = 0.02$) and more time in combined moderate to vigorous PA (MVPA, $p = 0.01$). There was a significant gender, ethnicity, and overweight interaction for total PA and MVPA (both $p < 0.01$). MVPA and counts per minute were significantly lower in overweight non-Hispanic girls and Hispanic boys ($p < 0.05$) and marginally lower in overweight non-Hispanic boys ($p = 0.10$) when compared with non-overweight students, while overweight Hispanic girls were more physically active than Hispanic non-overweight girls, though the difference was non-significant ($p > 0.05$). **Conclusions.** Data from the present study does not consistently support the prevailing hypothesis that overweight subjects engage in less PA. Results show overweight students engage in less PA than non-overweight students, with the exception that non-overweight Hispanic girls do not engage in more PA than their overweight peers. These results suggest the need for further investigation into the role that ethnicity and overweight status plays in PA levels, particularly among ethnic and gender sub-groups.

Key words: Actigraph, accelerometer, accelerometry, pediatric, obesity, physical activity

Introduction

The prevalence of pediatric obesity has increased in the US at an alarming speed and is disproportionately affecting ethnic minorities, including Hispanic children (1). The negative health consequences of pediatric obesity, such as metabolic risk factors and Type II diabetes, have also disproportionately impacted Hispanic children (2). In addition to the problems related to overweight in childhood and adolescence, overweight is associated with cancer and cardiovascular disease in adulthood (3,4). In any developmental stage, the ailments related to obesity constitute important public health concerns, and in response to some of these concerns, the Centers for Disease Control and Prevention (CDC) expert panel

has identified the need for studies that identify factors associated with and predictive of children's physical activity behaviors (5). To successfully develop future interventions aimed at preventing and treating pediatric overweight and its comorbidities particularly in Hispanic populations, the complex relationships between overweight and its various correlates, such as physical activity, need to be examined further.

Research has been inconclusive about the intricate relationships among overweight status, ethnicity, gender, and physical activity, specifically in pediatric populations. While some previous studies, using both subjective and objective measures of physical activity, have shown that overweight children are less likely to be physically active than their

non-overweight peers (6,7,8), other studies using accelerometers to assess physical activity have shown that there are no differences in physical activity in overweight and non-overweight children (9,10). The gender differences in physical activity in both survey- and accelerometer-based studies are more consistent; boys typically engage in more physical activity than girls (11,12).

The interaction of the effects of gender, ethnic and overweight status sub-groups on physical activity is more complex. For instance in a large-scale survey-based study of US children, Gordon-Larsen et al. (13) found the odds of overweight decreased with higher levels of moderate to vigorous physical activity among white boys and Hispanic boys and girls but not white girls. Similarly, Trost et al. reported overweight boys were significantly less physically active than their non-overweight peers when using the Actigraph in a sample of 60% African American preschoolers, and no differences were found in girls (14). In both studies, the association between overweight and physical activity was less clear in girls than boys, indicating that something other than physical activity may be contributing to the caloric imbalance causing overweight in girls.

To date, accelerometers have not been widely used to examine the influences of gender, and overweight status on physical activity in Hispanic children. The purpose of this cross-sectional study was therefore to examine the specific effects of ethnicity, gender, and overweight status on objectively measured physical activity in fourth grade children. We hypothesized that overweight subjects are less physically active at all physical activity intensities than non-overweight subjects, girls are less physically active than boys, and physical activity would be similar in Hispanic versus non-Hispanic children.

Methods

Participants, Design

Participants were recruited from four elementary schools within the West Covina school district in Los Angeles County, California during the fall of 2002 for baseline measurements of 'The Interactive Multimedia for Promoting Physical Activity' (IMPACT) study. The main findings from this cohort have been previously published (15), but did not include an analysis of the effects of ethnicity, gender, and overweight status on physical activity. In these four schools, consent forms were distributed to the parents of all fourth grade students ($n=307$ children), and 209 of these families provided consent

(68% recruitment yield). The schools were matched for socioeconomic status and ethnic composition. The present study included 169 students who had complete height, weight, questionnaire, and accelerometer data at baseline. Written parent consent and student assents were obtained prior to the start of the study, and the Institutional Review Board at the University of Southern California approved the study.

Anthropometry and demographic variables

Height (to 0.1 cm) and weight (to 0.1 kg) were measured by study staff according to standardized procedures with participants dressed in light clothing and without shoes. Body mass index (BMI) was calculated, and age and gender specific percentiles were calculated using Epi Info software, software developed by the Centers for Disease Control and Prevention (CDC), and CDC growth curves for pediatric populations (16). All participants with BMI $\geq 85^{\text{th}}$ percentile for age and gender were classified according to CDC guidelines as at risk for overweight and overweight, which will be referred to as overweight throughout this manuscript for the sake of brevity, and participants with BMI $< 85^{\text{th}}$ were classified as not at risk for overweight, which will be referred to as non-overweight. Prevalence rates of overweight and obese were also calculated according to the International Obesity Task Force guidelines, which used current adult BMI cut-offs and results from nationally representative studies from six countries to develop age- and sex- specific cut-off points for BMI for overweight and obesity in children (17).

The participants' gender was collected from the participant-completed questionnaire. The ethnicity of each participant was collected from the parent-completed demographic survey, and each participant was categorized as Hispanic or non-Hispanic. Participants were classified as Hispanic if the parent reported both maternal and paternal grandparents were of Hispanic descent. If ethnicity information was missing from one parent, then the participant was classified as being 'of unknown ethnicity' and excluded from the present analysis.

Measurement of physical activity assessed by accelerometry

To assess physical activity, subjects wore the Actigraph accelerometer, a uniaxial device measuring movement largely in the vertical plane, for a minimum of six waking hours per day for five consecutive days (including two weekend days). The Actigraph, has been validated for use with children (18–21),

has high inter-instrument reliability and has strong correlations with energy expenditure (18).

The participants were instructed to wear the monitors on the right hip under clothing (attached to an adjustable belt) at all times, except during water-based activities or when sleeping (20,22–25). The accelerometers were set to monitor activity in one-minute sampling intervals (epochs) as previously described (18,19,23). Previous research has observed no systematic within child, within day variation in accelerometry output (i.e., time of day effects) (22).

Accelerometry data were reduced using a custom software program developed by Dr. John Sirard at University of Minnesota. Criteria were established to determine valid accelerometry data; blocks of time with at least 20 continuous minutes of “0” output were considered times when the participant was not wearing the monitor and not a valid representation of his/her activity level. As a result, these data points were not used in the analyses. Count per minute values $\geq 15\,000$ and days with less than six hours of data were not included in any calculations, because the data were not considered representative of activity level (26). Only participants with two or more days of acceptable accelerometry data from baseline were included in the analysis for this study. In the current sample, participants wore the accelerometers for an average (mean \pm standard deviation, SD) of 4.3 ± 0.9 days and 12.5 ± 1.4 hours/day. These physical activity measurement criteria result in an acceptable physical activity-monitoring period with reliability coefficient of 0.71 (27).

Data were averaged across all acceptable days and included the following variables: number of days, average number of minutes worn on those days, average percent of time across days that the unit was worn, percent of time the monitor was worn across all acceptable days spent in sedentary behaviors, light intensity physical activity, and combined moderate to vigorous physical activity (MVPA), using accelerometer published cut-off values for pediatric populations (19). Sedentary behaviors (< 800 counts; < 0.015 kcal/kg/min) included activities, such as video/computer play and watching television; light physical activity (< 3200 counts; ≥ 0.015 and < 0.05 kcal/kg/min) included activities, such as stretching and walking at 2.5 mph; and MVPA included activities, such as basketball and jogging at 5 mph (≥ 3200 counts; ≥ 0.05 kcal/kg/min).

Statistical analysis

Statistical analyses were conducted using SAS software, Version 9.1 (SAS Institute Inc., Cary, NC). General linear models (GLM) were used to examine

the relationship between the independent variables (i.e., ethnicity, gender, and overweight status) and the dependent variables (i.e., total physical activity (cpm), sedentary behaviors, light physical activity, and MVPA). Analysis of variance (ANOVA) was used to examine the main and interaction effects of ethnicity, gender, and overweight status. When the gender \times ethnicity \times overweight interaction term was significant in the ANOVA ($p < 0.05$), the data were stratified by gender and ethnicity, and the relationships between overweight status and physical activity were examined. As the hierarchical nature of the data (individuals nested within schools) violates the linear regression assumption of independence increasing the likelihood of a type I error, intraclass correlations (ICC) were calculated to determine if multilevel model analysis was necessary. For each outcome variable of interest, the ICC was less than 0.01 so it was decided that multilevel model analysis was unnecessary.

Results

Characteristics of participants are shown in Table I. Satisfactory adherence to the measurement protocol for physical activity was achieved for 169 children. Of these, 50% were female, 63% Hispanic, and 43% were classified as overweight with a BMI percentile $\geq 85^{\text{th}}$ percentile based on previously discussed CDC growth charts. According to the guidelines set forth by the International Obesity Task Force, 24.3% of students in the current sample were overweight and 15.4% of the students were obese (17).

Students with complete demographic, overweight, and physical activity data ($n = 169$) were not statistically significantly different from those with missing data ($n = 18$) with regard to proportion female (50 vs. 56%, respectively; $p = 0.6$), proportion Hispanic (63 vs. 56%; $p = 0.5$), or proportion with BMI $\geq 85^{\text{th}}$ percentile (43 vs. 28%; $p = 0.2$).

First, the main effects of gender, ethnicity, and overweight status on total physical activity (counts per minute, cpm), sedentary behaviors, light intensity physical activity, and MVPA were investigated; means \pm SD were reported. Total physical activity, expressed as accelerometer counts per minute averaged over the five-day measurement period, is presented in Figure 1. Mean total physical activity for the group was 614 ± 178 cpm. Overweight and gender were significantly associated with total physical activity (cpm). Non-overweight students recorded significantly more counts per minute than overweight students (635 ± 198 cpm vs. 585 ± 143 cpm, respectively; $p = 0.04$). Boys engaged in total physical activity significantly more than girls

Table I. Characteristics of participants (mean \pm standard deviation).

	Group (n = 169)	Overweight (n = 72)	Non-Overweight (n = 97)
Gender (% female)	49.5%	43.6%	52.3%
Ethnicity (% Hispanic)	63.0%	69.2%	58.8%
Age (years)	9.4 \pm 0.4	9.5 \pm 0.4	9.4 \pm 0.4
Height (m)	1.4 \pm 0.1	1.4 \pm 0.1	1.3 \pm 0.1
Weight (kg)	36.2 \pm 9.2	44.7 \pm 8.6	30.9 \pm 4.9
BMI* (kg/m ²)	19.5 \pm 3.8	23.1 \pm 3.0	16.9 \pm 1.5
BMI Z score	0.8 \pm 1.0	1.7 \pm 0.4	0.1 \pm 0.8
Total physical activity (cpm [±])	614 \pm 178	585 \pm 143	635 \pm 198
Number of days accelerometer worn	4.1 \pm 0.9	4.4 \pm 0.8	3.9 \pm 1.0
% Time in sedentary PA	76.8 \pm 6.0	77.2 \pm 5.3	76.5 \pm 6.4
% Time light PA [‡]	19.7 \pm 4.5	19.6 \pm 4.1	19.5 \pm 4.8
% Time in MVPA	3.6 \pm 2.3	3.1 \pm 1.9	3.9 \pm 2.6

*BMI: body mass index; [±]cpm: counts per minute; [‡]percent of time spent in light intensity physical activity; ^{||}%MVPA: percent of time spent in moderate plus vigorous physical activity.

(658 \pm 193 cpm and 568 \pm 149 cpm, respectively; $p < 0.01$). Hispanic ethnicity was marginally associated with total physical activity; non-Hispanic students reported more physical activity than Hispanic students (646 \pm 181 cpm vs. 596 \pm 177 cpm, respectively; $p = 0.08$).

As a group, students spent a mean of 77 \pm 6% of their time in sedentary behaviors. There was a significant gender difference in percentage of time spent in sedentary behaviors; girls spent a significantly higher percentage of their time in sedentary behaviors than boys (78 \pm 6% vs. 76 \pm 7%; $p = 0.02$). There was not a significant difference by ethnicity (non-Hispanic 76 \pm 8% vs. Hispanic 77 \pm 6%; $p = 0.2$) or overweight status (non-overweight 77 \pm 7% vs. overweight 77 \pm 6%; $p = 0.5$).

In total, participants spent a mean of 20 \pm 5% of their time in light intensity physical activity. There was no significant difference in the amount of time spent in light physical activity by ethnicity (non-Hispanic 20 \pm 6% vs. Hispanic 19 \pm 6%; $p = 0.4$),

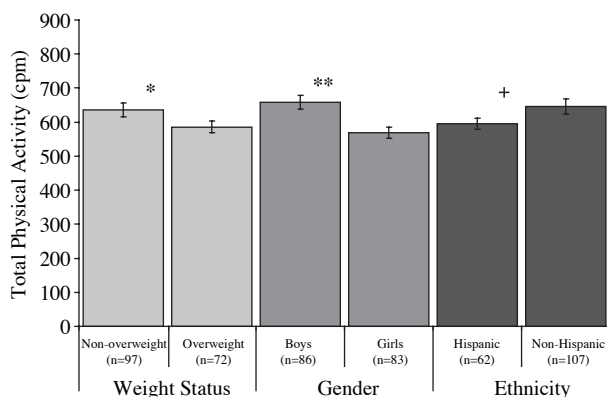


Figure 1. Mean counts per minute (cpm) by overweight status, gender and ethnicity. NOTE: cpm = counts per minute; overweight defined as BMI \geq 85th percentile for age and gender; ⁺ $p < 0.1$, ^{*} $p < 0.05$, ^{**} $p < 0.01$. Error bars represent standard errors of means.

gender (boys 20 \pm 5% vs. girls 19 \pm 5%; $p = 0.4$), or overweight status (overweight 20 \pm 6% vs. non-overweight 20 \pm 5%; $p = 0.9$).

The mean percentage of monitored time spent in MVPA for all subjects was 4 \pm 2%. There was a statistically significant difference in time spent engaged in MVPA between boys and girls (4 \pm 3% vs. 2 \pm 1%, respectively; $p = 0.01$). A trend was evident in the differences in MVPA by ethnicity (non-Hispanic 4 \pm 3% vs. Hispanic 3 \pm 2%; $p = 0.07$) and overweight status (non-overweight 4 \pm 3% vs. overweight 3 \pm 2%; $p = 0.07$).

To examine the intensities of physical activity in the subgroups, the interaction between gender, ethnicity and overweight status was then investigated. A statistically significant 3-way interaction was observed for total physical activity level ($p < 0.01$) and percentage of time spent in MVPA ($p < 0.01$); a trend toward a significant interaction was observed for percentage of time spent in sedentary behaviors ($p = 0.08$). The data were then stratified for the sub-group analyses, and results from models with a significant interaction are presented below. None of the sub-group analyses were significant for the amount of time spent in sedentary behaviors.

The gender, ethnicity, and overweight subgroup analyses for total physical activity (cpm) are illustrated in Figure 2. Higher levels of physical activity were observed in non-overweight students compared with overweight students in Hispanic boys (683 \pm 219 cpm vs. 582 \pm 163 cpm, respectively; $p = 0.03$), in non-Hispanic girls (625 \pm 179 cpm vs. 509 \pm 99 cpm, respectively; $p = 0.03$), and marginally in non-Hispanic boys (736 \pm 199 cpm vs. 651 \pm 132 cpm, respectively; $p = 0.10$). Conversely in Hispanic girls, overweight girls engaged in more total physical activity than non-overweight girls, though

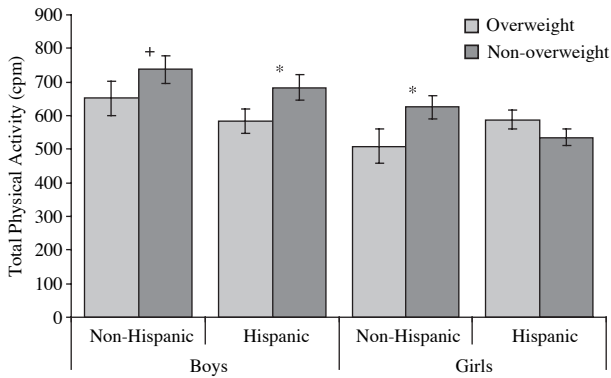


Figure 2. Mean counts per minute (cpm) by overweight status, gender and ethnicity. NOTE: cpm = counts per minute; overweight defined as BMI $\geq 85^{\text{th}}$ percentile for age and gender; ⁺ $p < 0.1$, ^{*} $p < 0.05$. Error bars represent standard errors of means.

the difference was non-significant (588 ± 128 cpm vs. 534 ± 142 cpm, respectively; $p = 0.16$).

A similar relationship in the gender, ethnicity, and overweight subgroups was found for MVPA. A higher percentage of time was spent in MVPA by non-overweight students compared with overweight students in Hispanic boys ($4.8 \pm 2.9\%$ vs. $3.2 \pm 2.1\%$, respectively; $p = 0.01$), in non-Hispanic girls ($3.6 \pm 1.7\%$ vs. $1.9 \pm 0.9\%$, respectively; $p < 0.01$), and marginally in non-Hispanic boys ($5.5 \pm 2.9\%$ vs. $4.3 \pm 1.9\%$, respectively; $p = 0.10$). In Hispanic girls, however, overweight girls engaged in more total physical activity than non-overweight girls, though the difference was non-significant ($2.9 \pm 1.5\%$ vs. $2.5 \pm 1.6\%$, respectively; $p = 0.33$).

Discussion

To our knowledge, this is the first study to objectively examine and compare total physical activity and patterns of physical activity in Hispanic (compared with non-Hispanic) elementary school-age children across weight categories using accelerometers. Our major finding is the presence of a significant overweight, gender, and ethnicity interaction effect for total physical activity (cpm) and MVPA. As expected, we found that in non-Hispanic students and Hispanic boys, overweight students had less total physical activity than their normal weight peers. In Hispanic girls, however, we found overweight students had a higher total physical activity than their normal weight counterparts, though the difference was non-significant. Our findings in non-Hispanic students and Hispanic boys support the prevailing hypothesis that lack of physical activity is an important contributing factor to the development and the continued maintenance of childhood obesity (28). However, the findings in Hispanic girls

demonstrate that an inverse relationship between physical activity and overweight status cannot always be assumed in subgroups of the population.

One possible explanation for the lack of difference in physical activity between overweight Hispanic and non-overweight Hispanic girls is that energy intake, not energy expenditure, is a more important factor influencing overweight status in Hispanic girls. While the increased physical activity of the overweight Hispanic girls expends more calories, they may be compensating by consuming more calories, leading to an energy imbalance and their overweight status. Studies solely measuring energy intake by direct observation and 24-hour dietary recall have reported that overweight children consume more calories than their non-overweight peers (29). Data also suggest that under-reporting of energy intake by as much as 20% of energy needs is significantly higher in overweight children and adults (30,31). Unfortunately, caloric intake was not assessed in this study so we are unable to examine the contribution of energy intake to overweight status.

Another possible explanation for these findings is the existence of a participant demand characteristic. As the students were wearing the accelerometers, reactivity may have occurred. Robinson et al. (32) reported Hispanic third grade girls have significantly more concerns about being overweight than non-Hispanic whites and Asian Americans. It is possible that these increased overweight concerns could have caused the overweight girls to increase their physical activity levels when wearing the accelerometers. Further studies may help elucidate whether reactivity is occurring in any of the overweight subjects in the gender and ethnic subgroups.

As cited earlier, Gordon-Larsen et al. (13) found the odds of overweight decreased with high levels of moderate and vigorous physical activity among Hispanic boys and girls. On the contrary, we did not find an association between physical activity and overweight in Hispanic girls, and our findings may suggest that physical activity was positively associated with overweight in Hispanic girls. This difference may be attributable to the use of self-report physical activity recall data in the Gordon-Larsen et al. study versus the accelerometry data used in the current study. The difference may also be attributable to the ages of the participants in the studies (4th grade in the current study and 7th–12th grade in Gordon-Larsen et al.).

Trost et al. (14) reported that overweight boys were significantly less active than non-overweight boys when using two objective measures of physical activity (accelerometry and direct observation) in a 60% African American sample, but no significant differences were observed in girls. Direct comparisons

between the findings of Trost et al. and the current study are complicated by the different ethnic compositions of the studies (60% African American vs. 64% Hispanic in the current study), and lack of information about the proportion of Hispanic youth in the Trost et al.'s sample. Furthermore, the analytical techniques used in the two samples were different. Despite the differences in methods, the findings in Trost et al. support our conclusions that an inverse relationship between physical activity and overweight status cannot always be assumed.

An interesting aspect of these findings is the lack of physical activity that is measured in this sample. Though there are at least marginally significant differences in physical activity between overweight and non-overweight Hispanic boys (difference = 100 cpm), non-Hispanic boys (difference = 116 cpm), and non-Hispanic girls (difference = 85 cpm) and non-significantly between non-overweight and overweight Hispanic girls (difference = 54 cpm), these differences are not clinically significantly different considering the cut-off activity above sedentary behavior (light physical activity) is 800 cpm (19).

One strength of this study is the use of accelerometers to measure physical activity. Measuring physical activity in children poses many challenges. Survey-based self-report measures are not recommended for children under the age of 10 years (33); and while direct observation can provide a valid assessment of children's physical activity (34), it is costly and time-consuming making it impractical for large-scale epidemiological research. Accelerometry, on the other hand, provides a practical and accurate means of objectively assessing engagement in physical activity. Accelerometers, a widely accepted measure used in research with children (20,21,25,33), provide objective measures that quantify the duration and intensity of physical activity. They have been used to measure free-living physical activity levels of children (23,33) and have been shown to be feasible for use in large-scale, population-based studies with children (23,24). While pedometers simply count the number of steps taken, accelerometers with the aid of accelerometer specific cutoffs are able to discriminate between light, moderate, and vigorous physical activity levels (18,19,35).

The present study had several potential limitations that warrant consideration. Due to the cross-sectional design of the study, no causal inference can be concluded between physical activity and weight status. Also, in principle bi- or tri-axial accelerometry (measurement of movement in other planes) *may* have provided more accurate measurement of physical activity than the (uniaxial) system used, but in

practice this benefit has not been demonstrated (20,21). Shorter activity monitoring intervals than the one-minute period used in the present study would *theoretically* have provided greater confidence in the assessment of time spent in vigorous activity, but again empirical evidence suggests this is not beneficial in practice (36).

Another potential limitation is that the definition of overweight status is based on each child's BMI percentile adjusted for age and gender. While this method is common in larger-scale studies with children, it has been shown that weight for height indices are flawed measures of adiposity (37). Future studies should assess adiposity with more accurate and precise measures of body composition. The unique ethnic composition of the schools involved in the study sample raises the question of whether these results would be generalizable to other schools. However, mixed racial and ethnic composition is common among schools in Los Angeles County, and we believe these schools accurately represent the school populations in Los Angeles.

Finally, the duration the accelerometer was worn (i.e., mean <5 days/week) is also a potential limitation. Although five days is a common time of measurement, one concern is that normal physical activity levels are not accurately captured, because there is currently a lack of consensus on how many days are needed for a reliable measure of habitual physical activity in children (21). While seven days has now become the preferred standard, Trost et al. have shown that in children, four to five days of activity has a measurement reliability of 0.80 (38). As such, we considered five days (with an average of 4.3 days and reliability coefficient of 0.71) to be an adequate length of measurement.

In summary, this examination of an ethnically diverse sample of fourth graders found non-overweight students engage in more physical activity than their overweight peers with the exception of non-overweight Hispanic girls, who do not engage in more physical activity than their overweight peers. Future research studies should concurrently examine the contributing roles of physical activity and energy intake to overweight status in Hispanic girls. Further investigations into the role of overweight status on physical activity in Hispanic girls may also help to inform interventions aimed at decreasing adiposity and reducing negative health outcomes in this population.

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The results of the present study do not constitute endorsement by the authors or IJPO of the products discussed in this paper.

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