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The effect of active brain-breaks during a typical school day on the in-school physical activity patterns of Grade 1 children in the Western Cape, South Africa

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ABSTRACT

The aim of the current study was to investigate the impact of classroom-based physically active brain-breaks on the in-school activity levels of Grade 1 (six- to eight-years-old) learners ($N=48$) by comparing baseline results to the intervention PA patterns of the participants. Children wore Actigraphs accelerometers for five consecutive school days, and thereafter they participated in a six-week active brain-breaks (10-minute bouts of PA) intervention. On a typical school day, children spend an average of 106.2 ± 30.9 minutes in sedentary behaviour, 43.7 ± 13.7 minutes in moderate PA and 26.5 ± 13.6 minutes in vigorous PA. No differences were found between boys and girls. During the intervention, the children's sedentary behaviour decreased (100.1 minutes) and their vigorous PA increased (34 minutes). The results emphasise the importance of participation in daily FMS and PA in order to increase Grade 1s' in-school PA patterns and decrease sedentary behaviour.

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KEYWORDS

Physical activity; sedentary; interventions; moderate-to-vigorous PA; monitor; physical activity patterns

Introduction

The physical activity (PA) guidelines proposed by the World Health Organization (WHO) recommend that children should participate in 60 minutes of moderate-to-vigorous physical activity (MVPA) per day (McLellan et al. 2020). South Africa's 2018 Report Card on Physical Activity for Children and Youth reported that between 48 and 51.7% of children meet the 60-minute requirement of MVPA per day (Draper et al. 2018). Furthermore, Cooper et al. (2015) concluded that less than 40% of children between the ages of nine and ten-years old in 10 different countries meet the daily recommended guidelines. According to the WHO, these recommended guidelines play an important role in children's movement behaviours, development and the prevention and management of childhood obesity and non-communicable diseases (Draper et al. 2020). It is evident that a great portion of South African school children are overweight and obese (Müller et al. 2019). There is a positive relationship between PA, health and the overall well-being of a child (McLellan et al. 2020); therefore, it is crucial to ensure that children participate in PA to decrease inactivity. This means that there remains concern to examine effective ways to enhance children's PA (Draper et al. 2018).

Walter (2011) measured the in-school PA patterns of South African children during school time (five consecutive school days) using Actigraph accelerometers. The results indicate that children spend 35 minutes of their school day participating in MVPA, which contributes to 58% of the daily recommended guidelines. Another South African study explored the PA patterns of children

and concluded that boys were more active than girls (Van Biljon et al. 2018). Tomaz et al. (2020) also measured the PA patterns of South African children using Actigraph accelerometers and concluded that children participated in 37 minutes of MVPA per day. The majority of the children in the Tomaz et al. (2020) study met the daily recommended guidelines of MVPA. Tremblay et al. (2017) purport that although global efforts have been implemented to increase PA and decrease sedentary time, the issue remains a challenge for governments, schools, therapists, teachers and parents.

Schools present an ideal environment for the implementation of PA and classroom-based interventions that can potentially enhance children's in-school PA levels and contribute to the recommended guidelines as stipulated by the WHO (Pate et al. 2006). Primary school children spend an average of 6 hours per day at school, and 65% of this time is spent being sedentary (Hegarty et al. 2016). Clemes et al. (2015) also contend that many children are sedentary during a typical school day as they sit most of the time. The school environment can, therefore, be the hub where interventions can be implemented in order to make a difference in children's PA levels (Dobbins et al. 2013). Children who adopt sedentary behaviour are more likely to experience cardiometabolic risk factors and lower self-esteem, as well as possible lower cognitive development (Mazzoli et al. 2019). School-based interventions can also possibly decrease risk factors for the development of chronic diseases (Müller et al. 2019). As researchers, teachers, parents and therapists try to increase the PA levels of children during and after school hours, there is a necessity to monitor the PA patterns of children during the day (Malan and Nolte 2017). Monitoring children's in-school PA patterns can provide an indication of whether children participate in an adequate amount of PA during the day. Additionally, monitoring their PA patterns can determine the effect of PA interventions on children's PA levels (Malan and Nolte 2017). In South Africa, school children are exposed to daily lunch breaks where they can play, as well as participate in physical education (PE) class once per week (between 40 and 45 minutes). However, the stand-alone status of PE as a school subject is unfortunately losing its importance in South African schools (Draper et al. 2018). Fundamental movement skills (FMS) are locomotor, object control and stability skills, which are the basic movement patterns that children between the ages of four and seven years old require (Barnett et al. 2016). FMS need to be practised continuously (Barnett et al. 2016); making it crucial for children to master these skills to enable the development of positive PA trajectories throughout life and to start partaking in sport-specific skills. Therefore, the need to investigate the implementation of classroom-based activities, such as active brain-breaks, could possibly enhance children's FMS and increase PA (Egger et al. 2019).

Active brain-breaks are short bouts of PA without educational content, which take place inside a classroom (Norris et al. 2019). During active brain-breaks, children participate in a variety of PA in the classroom that provides an opportunity to take a short break from academic work and potentially increase their in-school PA levels (Salmon 2010; Watson et al. 2017). By monitoring active brain-break interventions, the current study could provide an indication of whether any changes took place in the PA levels of children during a typical school day. Implementing classroom-based PA interventions, such as active brain-breaks could potentially help children to be more active during the day, decrease sedentary time in the classroom, improve PA, enhance attention and on-task behaviour, as well as improve academic achievement (Mazzoli et al. 2019; Ma, Le Mare, and Gurd 2015). To date, only one study has implemented a classroom-based brain-break intervention in South Africa (Mok et al. 2020). The aforementioned study examined a three- to five-minute active brain-break intervention (twice a day, five days a week over a four-month period) via videos and determined the children's attitudes toward PA by using a questionnaire (Mok et al. 2020). The most important finding from the study of Mok and colleagues was that the PA breaks improved the children's attitude toward PA.

The current study focused on a classroom-based active brain-break intervention with a focus on FMS, mainly because a good FMS foundation can over time lead to the development of PA that is in line with the Stodden model (Hulteen et al. 2018). No study in SA has investigated an FMS active brain-break intervention and the effect it has on children's PA levels during a school day. The

current study only explored the in-school PA of children, children in South Africa spend a large portion of their day at school and this is the best way teachers can assist them to be more active and develop their FMS. The activities of the intervention were based on integrated neuromuscular training (INT) programmes, which are based on various essential gross motor skills, such as locomotor and object control skills (FMS) (Faigenbaum, Farrell, and Fabiano 2011; Duncan, Eyre, and Oxford 2017). This study examined the following research question; Do classroom PA brain-breaks impact the in-school activity levels of Grade 1 children from the Western Cape?

Methods

Participants

This was a Comparative Effectiveness Research design (CER) (pre- post-test design with no control group) as well as a descriptive study design. The purpose of a CER study is to address the effectiveness of an intervention and does not necessarily have to be compared with a control group, thereafter the intervention can be revised and researchers can make recommendations of what benefits the intervention demonstrated as well as what the gaps are. CER is important as it is designed to improve health care decision making by giving evidence about the efficacy and benefits of specific interventions (Concato et al. 2010).

Following institutional approval (#8456) from the Research Ethics Committee (REC) of the institution involved and the Education Department of the region, six- to eight-year-old children from a school in the Western Cape Province, South Africa, ($N = 48$ [$n = 28$ boys and $n = 20$ girls]), volunteered to participate in the current study. Written consent from the parents/ legal guardians and assent from the children were obtained prior to participation. The school had three Grade 1 classes; two classes formed the experimental group. Participants were included in the study if: they were in Grade 1, attended the selected schools, parents completed the informed consent form and the children signed the assent form. Participants were excluded if they had a hearing or sight impairment, were unwilling to participate in the measurements, had severe medical conditions, for example, heart or ear defect, and were unable to run or jump or miss more than 30% of the intervention.

Procedures

The data collection and intervention took place at the specific school. Accelerometers monitored the children's in-school PA patterns during five consecutive school days before the intervention started (baseline testing), as well as on four days during the intervention. The devices were placed on the children's dominant wrist at 08:00 in the morning and were taken off at 13:00 in the afternoon. Each monitor had a unique code to ensure each child wore the same monitor every day. The researcher kept a daily logbook of the exact times the accelerometers were placed on and taken off in order to make the non-wear time easily recognisable during the data analysis.

Intervention

The two experimental classes participated in a 10-minute classroom-based active brain-break intervention twice a week over 6 weeks, which added up to 24 active brain-breaks. The first active brain-break took place early in the morning (between 08:15 and 08:45) and the second one later in the morning (between 10:30 and 11:00). The specific times of the intervention were allocated by the schools and the researcher had no control over them. The active brain-breaks took place in the classroom behind each child's desk/chair or on the carpet. The intervention had no effect on the school curriculum of the children, and the researcher had no control over what the children did during the rest of their school day. The researcher and two assistants were present at each session to explain

and demonstrate the activities until the children understood what to do, as well as to assist and correct the children where necessary and to ensure that the children participated in all the activities.

The self-designed active brain-breaks were based on INT programmes and incorporated locomotor and object control skills with the aim of enhancing and strengthening children's FMS and physical fitness levels (Duncan, Eyre, and Oxford 2017). The specific intervention activities (locomotor and object control skills) were chosen by the researcher, activities that needed minimal space to execute were chosen as well as activities that could have been done in different variations. The activities were chosen as they gave the children the opportunity to practice their FMS, which is necessary for their age. See Table 1 for the intervention outline and focuses. Two FMS (Table 1) were chosen each week. Recognising that FMS such as leap, gallop and slide are more difficult to master inside a classroom, specific attention was given to activities that attempted to develop these skills.

Accelerometry

Children's PA was measured using a wrist-worn Actigraph GT3X+ accelerometer (Actigraph LLC, Pensacola, FL; USA). Each device was programmed to capture data from 08:00 on Monday to 13:00 on Friday. The ActiLife version 16.13.4 (ActiLife LLC, Pensacola, FL; USA) was used to initialise and download in 5-second epochs, as well as to clean and score all data. Objective measurements such as accelerometers were used to monitor children's PA patterns, as well as to establish time spent being sedentary and/or in MVPA. This has become a more feasible and objective method than questionnaires and self-reported measurements (Migueles et al. 2017). Accelerometers, which measure the acceleration of body segments, can be worn on the hip, waist or wrist. In the literature, there is disagreement about whether hip- or wrist-worn placements are more accurate. Studies undertaken by Fairclough et al. (2012) and Berglind and Tynelius (2018), purports that the hip placement is more reliable. However, Noonan et al. (2018) found that wrist-worn devices presented more reliable results and children found them to be more comfortable than hip-worn devices. What is crucial is not only the placement of the device but also the classification of sedentary behaviour, moderate and vigorous PA. In some cases, sedentary time can be overestimated and MVPA underestimated or vice versa, or irregular PA data can be collected. Therefore, researchers face challenges when it comes to the appropriate classification of sedentary time and how to quantify it (Tremblay et al. 2017). Migueles et al. (2017) provide guidance to researchers regarding the placement of accelerometers, as well as different cut-points (time spent in sedentary behaviour, moderate and vigorous PA), that can be used.

The researcher made sure each participant wore the device during the day. The time that the children did not wear the device (between 13:30 and 08:00) was erased after data collection to avoid non-wear or sedentary time. Only data recorded from 08:00 to 13:00 was considered as a valid day and was considered for analysis. The devices were initialised to capture data at 100 Hz and the low-frequency extension was not enabled. Cut-points of Crouter et al. (2013) were used to determine the different intensities of PA. Sedentary <275, light physical activity (LPA) were between 276 and 415 counts per 5 seconds, moderate physical activity (MPA) between 461 and 777 counts per 5 seconds and vigorous physical activity (VPA) <778 counts per 5 seconds (Crouter et al. 2013).

Statistical analysis

Mixed model ANOVA was performed to compare activity times between the pre- and intervention zones. The participants were included as a random effect and gender zone and period as fixed effects. Fisher's least significant difference (LSD) was used for post hoc testing. Recognising within the pre-test measurements (baseline testing), that on day four, children participated in a PE lesson. This was atypical of their habitual PA patterns and would skew the pre data in terms of representing habitual PA, the analysis was rerun omitting this day's data. A comparison was made between the four days of pre-tests where no PE was present and the four specific days that the



Table 1. Continued.

Week Session	Warm-up (2 min)	Core activities (3 min)	Cool down (1–2 min)
4	13–16 Activities • Jump on & off a dot. • Run around & on a command stop & freeze. • Pass the beanbag to a friend while balancing on one leg. • Pass the ball under your legs.	Focus Cardiovascular & Balance Activity 1 • In a block perform a sequence given by a command, slide twice to the right & once to the left. • Slide in a circle following the direction of the arrows. • double leg hops & side lunge. • Fast slides in directions. Activity 2 • Strike swinging motion with a small stick. • Pair up & with small stick, do the strike motion & touch your friends back. • Strike a dot. • Strike & step forward & hug yourselves.	Focus Slide Focus Strike Focus Balance, Coordination & Strength • Sit with beanbag on the head & lift your feet for 10 seconds. • Plank for 10 seconds. • Stand & sit by asking fun questions. • Robot clap game
5	17–20 Activities • Pair up, back to back & give beanbag under, over & sideways to a friend. • Same as above but on one leg.	Focus Cardiovascular & Balance Activity 1 • Jump on & off a beanbag. • Stand on the beanbag & jump in directions as indicated. • Bend down & pick-up a beanbag, jump up & turn 180 degrees. • Stand behind the beanbag & go down & make your body as small as an egg & jump up & over the beanbag. Activity 2 • Bounce a ball to a friend. • Bounce & catch a ball without dropping the ball. • Dribble a ball around a square. • Pair up & dribble the ball & bounce to your friend.	Focus Jump Focus Balance, Coordination & Strength • Balance on one leg for as long as possible. • Star jumps. Focus Dribble Focus Balance, Coordination & Strength • Lie on your back & pretend to ride a bicycle. • Hook feet in with a friend & do sit-up.
6	21–24 Activities • Running jacks • Scissor jump • Run in a circle & on command jump like a frog. • Hopscotch on the spot.	Focus Cardiovascular, Coordination & Balance Activity 1 • Green card = balance on one leg & red card = heel-to-toe position. • Green card = frog jumps & red card = balance on non-dominant leg. • Green card = hop on dominant leg in block & red card = heel-to-toe position. • Hop with dominant foot in different blocks placed out. Activity 2 • Stand behind a cone & kick it. • Stand behind cone & balance on non-dominant leg & kick cone. • Run on the spot behind a cone & on command kick the cone. • In pairs, kick a tennis ball to your friend.	Focus Hop Focus Balance, Coordination & Strength • In a bear position lift up limbs on instruction. • Crab position for 10 seconds. • Caterpillar walk • Superman (aeroplane)

Table 2. Mean and SD for sedentary, moderate and vigorous PA.

	Sedentary (minutes)	Sedentary %	Moderate (minutes)	Moderate %	Vigorous (minutes)	Vigorous %
Overall (Baseline testing)	106.2 ± 30.9	35	43.7 ± 13.7	14	26.5 ± 13.6	8
Boys (Baseline testing)	108.1 ± 30.7	36	42.9 ± 13.0	14	26.2 ± 13.9	8
Girls (Baseline testing)	103.6 ± 31.2	34	44.8 ± 14.6	14	26.8 ± 13.9	8
Overall (During intervention)	100.1 ± 20.0	33	41.9 ± 11.6	13	34.1 ± 11.9	11
Boys (During intervention)	102.7 ± 18.7	34	41.9 ± 10.4	13	32.9 ± 11.0	10
Girls (During intervention)	96.5 ± 21.2	32	42.0 ± 13.1	14	32.9 ± 11.0	10

children participated in the active brain-break intervention. The Cohen's D effect sizes were determined to see if there were any practical differences.

Results

The final sample ($N = 48$) consisted of six- to eight-year-old learners ($M = 6.6$, $SD = 0.4$). Table 2 displays a composite score (five consecutive school days combined), of the mean and SD time (minutes) that the children spend in sedentary behaviour, moderate and vigorous PA during a typical school day from 08:00 to 13:00 (actual wear time = 300 minutes) as well as the percentage that children spend in sedentary behaviour, moderate and vigorous PA during the day. The activity zones are defined as sedentary, moderate and vigorous.

Figure 1 demonstrates the children's PA in each activity zone (sedentary, moderate and vigorous) during the pre-test and on the intervention days.

Figure 2 demonstrates the mean and SD for the sedentary behaviour, moderate and vigorous PA during four pre-test days (day four with PE lesson excluded) and the four days of the intervention.

There was a statistically significant difference ($p < .05$) (Figure 2) between the sedentary behaviour, moderate and vigorous PA of the participants. Figure 2 indicates increased activity in the

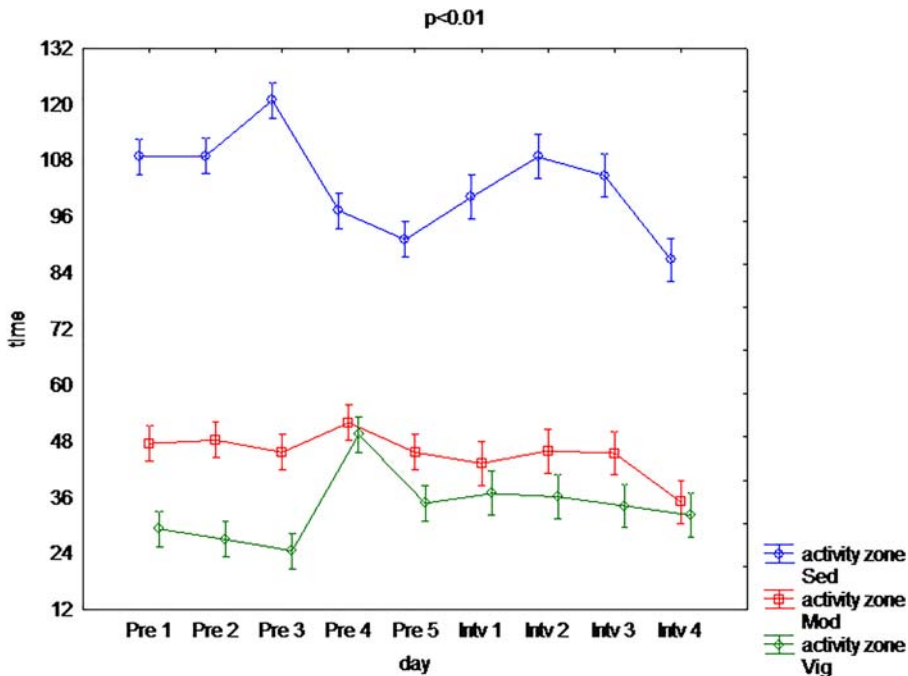


Figure 1. Sedentary, moderate and vigorous pa (mins) during pre-test and intervention.

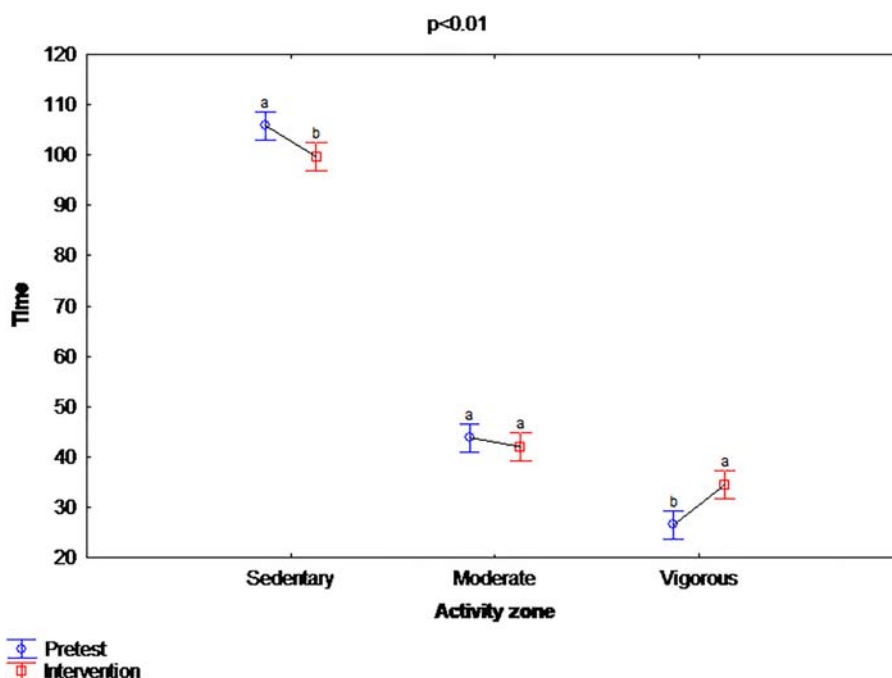


Figure 2. Sedentary, moderate and vigorous pa (mins) between pre-test and intervention.

intervention period due to a significant decrease of time spent in sedentary behaviour, coupled with increased time spent in vigorous PA. On a typical school day, participants spent an average of 106.2 minutes in sedentary behaviour, whereas during the intervention it was 100.1 minutes ($p < .01$), the Cohen's D effect sizes indicate a small practical difference (0.25). For moderate PA, participants spent an average of 44 minutes in this category and during the intervention, 41 minutes ($p < .01$), there was only a small practical difference (0.16) according to Cohen's D effect sizes. Lastly on a typical school day, participants spent an average of 26 minutes in vigorous PA and during the intervention 34 minutes ($p < .01$), the Cohen's D effect sizes indicate a medium practical difference (0.61).

Discussion

This study explored the in-school PA levels of the children on five consecutive school days, and thereafter the children participated in a six-week active brain-break intervention. During the pre-test, the children took part in a typical PE lesson on day four, after a second statistical analysis was performed; day four was excluded in order to see what the effect of the brain-breaks was. During the intervention, the children were monitored with accelerometers on four random days in order to determine if any changes took place in their sedentary behaviour, moderate and vigorous PA levels. The duration of each school day was 5 hours (300 minutes) from 08:00 to 13:00. Walter (2011, 2014) showed that the participants in their studies were 66% sedentary during a school day, which indicates that the participants in the current study were more sedentary than the children of Walter's study.

In the current study, children only had one 20-minute break during the school day. According to the guidelines of Pate et al. (2006) children should participate in 30 minutes of MVPA during a typical school day. In the current study, the children met the recommendations of Pate et al. (2010). Gidlow et al. (2008) found that children performed 29.3 minutes of MVPA during a school day (08:00–14:00). In the above-mentioned study, a statistically significant difference was evident between boys and

girls; boys were more sedentary than girls. The South African studies (Walter 2011; Van Biljon et al. 2018), concluded that boys were more active than girls. However, the children who participated in that study were older (8- to 14-years-old) than the population group of the current study.

As reported in the results, on day four the children participated in a typical PE lesson during which their vigorous PA demonstrated a tremendous spike and their sedentary behaviour decreased. Therefore, the researcher can speculate that participation in PE lessons can potentially increase children's in-school PA levels, especially because of the time duration of the lessons. However, the children only get exposed to one PE lesson per week. During the intervention of the current study, the participants had the opportunity to practise FMS on a regular basis and the aim was to determine whether active brain-breaks had an effect on their in-school PA levels. A statistically significant difference was found between the time that children were spending in sedentary behaviour and moderate PA, compared to the time spent in vigorous PA; the study found that they spent less time in sedentary behaviour and moderate PA and more time in vigorous PA. No statistically significant differences were found between boys and girls. The researcher can only speculate that the boys and girls partake in the same amount of PA during school time. Therefore, it could be speculated that the active brain-breaks increased the participants' in-school PA levels on the specific days that they participated in the intervention. In an attempt to increase primary school children's in-school PA levels, in the study done by Scruggs, Beveridge, and Watson (2003) a morning and lunch as well as a fitness break intervention was implemented during the school day, which lasted for 15 minutes and consisted of a variety of locomotor and non-locomotor activities. Scruggs, Beveridge, and Watson (2003) concluded that the fitness breaks increased the children's PA levels and contributed to their MVPA. Bershwiner and Brusseau (2013) implemented a study similar to the current one, where children were monitored using pedometers during a school day and thereafter activity breaks were conducted. The children's MVPA increased significantly when they participated in the activity breaks (Bershwiner and Brusseau 2013). Walter (2014) explored the PA patterns of primary school children using accelerometers and implemented a six-week intervention. The study concluded that the intervention increased the children's MVPA and decreased their sedentary behaviour time (Walter 2014). The increases in children's PA levels made a valuable contribution to the daily 60 minutes of MVPA recommendation (Walter 2014). A few studies (Whitt-Glover et al. 2011; Erwin, Koufroudakos, and Beighle 2013; Carlson et al. 2015; Calvert et al. 2017; Calella et al. 2019), monitored children using accelerometers and implemented 10- to 15-minute active brain-breaks and concluded that children were less sedentary and that the intervention contributed to their daily MVPA.

The current study examined the in-school PA patterns of children during a pre-test period and during classroom-based active brain-breaks. The results showed a significant increase in the vigorous PA patterns of the children during school time and consequently reduced sedentary behaviour as well. Thus, indicating that the active brain-breaks had a potential positive impact. It was clear that taking part in a PE lesson provided by the school can significantly increase their in-school PA levels. Therefore, the active brain-breaks can likely increase children's moderate and vigorous PA levels on the days where no PE is scheduled on the timetable. The active brain-breaks can be a good daily supplement and add on to their daily routine. Moreover, schools need to realise the tremendous effect that PE has on children's in-school PA levels and place more emphasis on PE on a weekly basis. However, it would provide added value if schools could implement active brain-breaks during the school day because it would potentially provide an opportunity for children to continuously practise FMS and increase their MVPA levels, especially on the days where there is no PE. The active brain-breaks could potentially contribute to the holistic development of children by enhancing their mental, physical, emotional and social development. Giving children the opportunity to engage in physical activities during their school day can have a positive outcome on their school performance and enhance concentration and attention, children will also feel more motivated and focused. Previous research found that classroom-based active brain-breaks had positive effects on children's on-task behaviour and academic performance and provided children with

the opportunity to take short breaks from academic work (Mazzoli et al. 2019). The current study only examined children's in-school PA levels during a typical school week (pre-test) and during randomly selected active brain-break days. Future studies could potentially implement active brain-breaks daily, as well as investigate which activities provided the most MVPA. The current study will make a valuable contribution to the South African literature on the PA levels of children and also indicate that it is practically possible and economical to implement active brain-breaks in the classroom to promote children's in-school PA during the day.

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References

- Barnett, L. M., D. Stodden, K. E. Cohen, J. J. Smith, D. R. Lubans, M. Lenoir, S. Iivonen, A. D. Miller, A. Laukkanen, D. Dudley, N. J. Lander, H. Brown, and P. J. Morgan. 2016. "Fundamental Movement Skills: An Important Focus." *Journal of Teaching in Physical Education* 35 (3): 219–225.
- Berglund, D., and P. Tynelius. 2018. "Objectively Measured Physical Activity Patterns, Sedentary Time and Parent-Reported Screen-Time Across the Day in Four-Year-Old Swedish Children." *BMC Public Health* 18: 69–77.
- Bershawinger, T., and T.A. Brusseu. 2013. "The Impact of Classroom Activity Breaks on the School-Day Physical Activity of Rural Children." *International Journal of Exercise Science* 6 (2): 134–143.
- Calella, P., C. Mancusi, P. Pecoraro, S. Sensi, C. Sorrentino, M. Imoletti, et al. 2019. "Classroom Active Breaks: A Feasibility Study in Southern Italy." *Health Promotion International* 35: 1–8.
- Calvert, H.G., M.T. Mahar, B. Flay, and L. Turner. 2017. "Classroom-Based Physical Activity: Minimizing Disparities in School-Day Physical Activity among Elementary School Students." *Journal of Physical Activity and Health* 15: 161–168.
- Carlson, J.A., J.K. Engelberg, K.L. Cain, T.L. Conway, A.M. Mignano, E.A. Bonilla, C. Geremia, J.F. Sallis. 2015. "Implementing Classroom Physical Activity Breaks: Associations with Student Physical Activity and Classroom Behaviour." *Preventive Medicine* 81: 67–72.
- Clemes, S.A., S.E. Barber, D.D. Bingham, N.D. Ridgers, E. Fletcher, N. Pearson, J. Salmon, D.W. Dunstan. 2015. "Reducing Children's Classroom Sitting Time Using Sit-to-Stand Desks: Findings from Pilot Studies in UK and Australian Primary Schools." *Journal of Public Health* 38 (3): 526–533.
- Concato, J., P. Peduzzi, G.D. Huang, T.J. O'Leary, and J. Kupersmith. 2010. "Comparative Effectiveness Research: What Kind of Studies Do We Need?" *Journal of Investigative Medicine* 58 (6): 764–769.
- Cooper, A.R., A. Goodman, A.S. Page, L.B. Sherar, D.W. Esliger, E.M. Van Sluijs, L.B. Andersen, and et al. 2015. "Objectively Measured Physical Activity and Sedentary Time in Youth: The International Children's Accelerometry Database (ICAD)." *International Journal of Behavioural Nutrition and Physical Activity* 12: 113–123.
- Crouter, S.E., D.M. Dellavalle, J.D. Haas, E.A. Frongillo, and D.R. Bassett. 2013. "Validity of ActiGraph 2-Regression Model and Matthews and NHANES and Cut-Points for Assessing Free-Living Physical Activity." *Journal of Physical Activity and Health* 10 (4): 504–514.
- Dobbins, M., H. Husson, K. Decorby, and R.L. Larocca. 2013. "School-Based Physical Activity Programs for Promoting Physical Activity and Fitness in Children and Adolescents Aged 6 to 18." *Cochrane Database Systematic Review* 2.
- Donnelly, J.E., C.H. Hillman, D. Castelli, J.L. Etnier, S. Lee, P. Tomporowski, K. Lambourne, and A.N. Szabo-Reed. 2016. "Physical Activity, Fitness, Cognitive Function, and Academic Achievement in Children: A Systematic Review." *Medicine & Science in Sport & Exercise* 48 (6): 1197–1222.

- Draper, C.E., S.A. Tomaz, S.H. Bassett, C. Burnett, C.J. Christie, C. Cozett, M. de Milander, et al. 2018. "Results from South Africa's 2018 Report Card on Physical Activity for Children and Youth." *Journal of Physical Activity and Health* 15 (2): S406–S408.
- Draper, C.E., S.A. Tomaz, C.J. Cook, S.S. Jugdav, C. Ramsammy, S. Besharati, A. Van Heerden, et al. 2020. "Understanding the Influence of 24-Hour Movement Behaviours on the Health and Development of Preschool Children from Low-income South African Settings: The SUNRISE Pilot Study." *South African Journal of Sports Medicine* 32 (1): 1–7.
- Duncan, M.J., E.L.J. Eyre, and S.W. Oxford. 2017. "The Effects of 10 Weeks Integrated Neuromuscular Training on Fundamental Movement Skills and Physical Self-Efficacy." *The Journal of Strength and Conditioning Research* 32 (12): 1–32.
- Egger, F., V. Benzing, A. Conzelmann, and M. Schmidt. 2019. "Boost Your Brain, While Having a Break! The Effects of Long-term Cognitively Engaging Physical Activity Breaks on Children's Executive Functions and Academic Achievement." *Public Library of Science* 14 (3): 1–20.
- Erwin, H., R. Koufrouidakis, and A. Beighle. 2013. "Children's Physical Activity Levels During Indoor Recess Dance Videos." *Journal of School of Health* 83: 322–327.
- Faigenbaum, A.V., A. Farrell, and M. Fabiano. 2011. "Effects of Integrative Neuromuscular Training on Fitness Performance in Children." *Pediatric Exercise Science* 23: 573–584.
- Fairclough, S.J., A. Beighle, H. Erwin, and N. Ridgers. 2012. "School Day Segmented Physical Activity Patterns of High and Low Active Children." *BMC Public Health* 12: 406–418.
- Gidlow, C.J., T. Cochrane, R. Davey, and H. Smith. 2008. "In-School and Out-of-School Physical Activity of Primary and Secondary School Children." *Journal of Sports Sciences* 26 (13): 1411–1419.
- Halpern, S.D., P.A. Ubel, and A.L. Caplan. 2002. "Solid-Organ Transplantation in HIV-Infected Patients." *New England Journal of Medicine* 347 (4): 284–287.
- Hegarty, L.M., J.L. Mair, K. Kirby, E. Murtagh, and M.H. Murphy. 2016. "School-Based Interventions to Reduce Sedentary Behaviour in Children: A Systematic Review." *Public Health* 3 (3): 520–541.
- Hulteen, R.M., P.J. Morgan, L.M. Barnett, D.F. Stodden, and D.R. Lubans. 2018. Development of Foundational Movement Skills: A Conceptual Model for Physical Activity Across the Lifespan." *Sports Medicine* 48: 1533–1540.
- Ma, J.K., L. Le Mare, and B.J. Gurd. 2015. "Four Minutes of In-Class High-Intensity Interval Activity Improves Selective Attention in 9- to 11-Year Old's." *Applied Physiology, Nutrition, and Metabolism* 40: 238–244.
- Malan, G.F., and K. Nolte. 2017. "Measuring Physical Activity in South African Grade 2 and 3 Learners: A Self-Report Questionnaire Versus Pedometer Testing." *South African Journal for Research in Sport, Physical Education and Recreation* 39 (3): 79–91.
- Mazzoli, E., H. Koorts, J. Salmon, C. Pesce, T. May, W. Teo, and L.M. Barnett. 2019. "Feasibility of Breaking up Sitting Time in Mainstream and Special Schools with a Cognitively Challenging Motor Task." *Journal of Sport and Health Science* 8: 137–148.
- McLellan, G., R. Arthur, S. Donnelly, and D.S. Buchan. 2020. "Segmented Sedentary Time and Physical Activity Patterns Throughout the Week from Wrist-Worn ActiGraph GT3X Accelerometers Among Children 7-12 Years old." *Journal of Sport and Health Science* 29: 179–188.
- Migueles, J.H., C. Cadenas-Sanchez, U. Ekelund, C.D. Nyström, J. Mora-Gonzalez, M. Löf, I. Labayen, J.R. Ruiz, F.B. Ortega. 2017. "Accelerometer Data Collection and Processing Criteria to Assess Physical Activity and Other Outcomes: A Systematic Review and Practical Considerations." *Journal of Sports Medicine* 47 (9): 1821–1845.
- Mok, M.M.C., M. Chin, A. Korcz, B. Popeska, C.R. Edginton, F.S. Uzunoz, H. Podnar, et al. 2020. "Brain Breaks Physical Activity Solutions in the Classroom and on Attitudes Toward Physical Activity: A Randomized Controlled Trial among Primary Students from Eight Countries." *International Journal of Environmental Research and Public Health* 17: 1666–1677.
- Müller, I., C. Schindler, L. Adams, K. Endes, S. Gall, M. Gerber, N. S. N.Htun, et al. 2019. "Effect of a Multidimensional Physical Activity Intervention on Body Mass Index, Skinfolds and Fitness in South African Children: Results from a Cluster-Randomised Controlled Trial." *International Journal of Environmental Research and Public Health* 16: 232–248.
- Noonan, R.J., L.M. Boddy, Y. Kim, Z.R. Knowles, and S.J. Fairclough. 2018. "Comparison of Children's Free-Living Physical Activity Derived from Wrist and hip raw Accelerations During the Segmented Week." *Journal of Sport Science* 35: 2067–2072.
- Norris, E., T. Van Steen, A. Direito, and E. Stamatakis. 2019. "Physically Active Lessons in Schools and Their Impact on Physical Activity, Educational, Health and Cognition Outcomes: A Systematic Review and Meta-Analysis." *British Journal of Sports Medicine* 0: 1–14.
- Pate, R. R., J. R. O'Neill, and J. Mitchell. 2010. "Measurement of Physical Activity in Preschool Children." *Medicine and Science in Sports and Exercise* 42 (3): 299–306.
- Pate, R.R., M.G. Davis, T.N. Robinson, E.J. Stone, T.L. McKenzie, and J.C. Young. 2006. "Promoting Physical Activity in Children and Youth: A Leadership Role for Schools." *Circulation* 114: 1214–1224.
- Salmon, J. 2010. "Novel Strategies to Promote Children's Physical Activities and Reduce Sedentary Behaviour." *Journal of Physical Activity and Health* 7 (3): 299–306.
- Scruggs, P.W., S.K. Beveridge, and D.L. Watson. 2003. "Increasing Children's School Time Physical Activity Using Structured Fitness Breaks." *Pediatric Exercise Science* 15 (2): 156–169.

- Tomaz, S.A., T. Hinkley, R.A. Jones, R. Twine, K. Kahn, S.A. Norris, and C.E. Draper. 2020. "Objectively Measured Physical Activity in South African Children Attending Preschool and Grade R: Volume, Patterns, Meeting Guidelines." *Pediatric Exercise Science*, 1–7.
- Tremblay, M.S., S. Aubert, J.D. Barnes, T.J. Saunders, V. Carson, A.E. Latimer-Cheung, S.F.M. Chastin, T.M. Altenburg, M.J.M. Chinapaw. 2017. "Sedentary Behaviour Research Network (SBRN) – Terminology Consensus Project Process and Outcome." *International Journal of Behavioral Nutrition and Physical Activity* 14: 75–92.
- Van Biljon, A., A.J. McKune, K.D. DuBose, U. Kolanisi, and S.J. Semple. 2018. "Physical Activity Levels in Urban-Based South African Learners: A Cross-Sectional Study of 7348 Participants." *South African Medical Journal* 108 (2): 126–131.
- Walter, C.M. 2011. "In-school Physical Activity Patterns of Primary School Learners from Disadvantaged School in South Africa: Health and Lifestyle." *African Journal of Physical, Health Education, Recreation and Dance* 2: 780–789.
- Walter, C.M. 2014. "Promoting Physical Activity: A Low Cost Intervention Programme for Disadvantaged Schools in Port Elizabeth, South Africa." *African Journal for Physical, Health Education, Recreation and Dance* 20 (2:1): 357–371.
- Watson, A., A. Timperio, H. Brown, K. Best, and K.D. Hesketh. 2017. "Effect of Classroom-Based Physical Activity Interventions on Academic and Physical Activity Outcomes: A Systematic Review and Meta-Analysis." *International Journal of Behavioral Nutrition and Physical Activity* 14: 114–138.
- Whitt-Glover, M.C., S.A. Ham, and A.K. Yancey. 2011. "Instant Recess: A Practical Tool for Increasing Physical Activity During the School Day." *Progress in Community Health Partnerships* 5: 289–297.