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Determining the Protocol and Testing Feasibility and Intensity of the Burn2Learn interventions and measures in college students

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Title: Determining the Protocol and Testing Feasibility and Intensity of the Burn2Learn interventions and measures in college students

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Introduction

Adolescents of today are experiencing declining levels of fitness in their everyday lives. Every year that adolescents age, there is a mean decline of 7% per year in physical activity level. Systemic reviews found that the physical activity change throughout adolescence is 60-70% (1). Some contributing factors to the decline in activity are caused by schools. Institutional barriers, such as crowded curriculum and lack of sufficient space for workouts, push physical activity to the periphery (2). This is clearly detrimental to the physical health of today's youth.

Physical fitness, single bouts of physical activity, and physical activity interventions benefit the cognitive functioning of children. Not only does physical activity have a positive influence on cognition, but also on brain structure and function (3). Children with higher fitness levels have greater bilateral hippocampal volumes than children with lower fitness levels. This relates to better accuracy in relational memory. VO2 max is positively correlated with both relational memory accuracy and the bilateral hippocampal volume (4). Higher fit children also have a higher ability to activate the prefrontal and parietal cortex which is beneficial in using higher level cognitive control. Higher fit children were able to have a high level of accuracy on a post-exercise cognitive control task with a decreased amount of brain activity. The lower fit children had a decrease in accuracy with no change in brain activity (5). This study concluded that higher fit children have a greater ability to activate frontal and parietal regions of their brain, something very beneficial for cognitive control and thus academic achievement (5). It is also known that physical activity is positively related to higher academic performance in children (6). Exercise improves executive function and math achievement in a specific dose-response manner (7).

One type of exercise that has been research for both physical and cognitive benefits is High intensity interval training. High-intensity interval training (HIIT) is a method of training that involves repeated short bouts of high-intensity exercise with short recovery periods in between. It is time-efficient and can improve cardiorespiratory and metabolic function through combined aerobic and resistance training methods (8). High intensity exercise improves executive function in a shorter duration of exercise (9). Furthermore, High Intensity Interval Training, HIIT, causes greater improvements in executive functioning compared to moderate intensity continuous exercise (10). HIIT is an effective and safe method to improve conditioning and weight loss. A major benefit of HIIT is that it can be carried out in any environment and reaps the same benefits in a shorter amount of time (11). A meta-analysis suggested that moderate-to-high cognitively demanding HIIT protocols more strongly affect execute functioning, while low cognitively demanding HIIT protocols tend to better affect well-being. Furthermore, the acute effects of HIIT were found to be stronger than the chronic effects in regards to cognitive function (9). A HIIT program implemented in a school in Australia, Burn2Learn, was well received by both students and teachers, suggesting high feasibility and acceptance rates. Teachers agreed that facilitating in-class HIIT sessions led to improvements in on-task and classroom behavior (12). In another HIIT program, adolescents who participated in a HIIT workout at the beginning of the school day increased their selective attention by 17.39% during the next hour. This suggests that HIIT can assist with attention and concentration in class

(13). While there have been multiple studies relating HIIT to cognitive functioning, none have come up with specific strategies to target and improve certain outcomes such as executive function and working memory.

The chronic effects of HIIT workouts that incorporate brain games have been studied, but I will be looking at the acute effects of HIIT workouts on cognitive functioning. The purpose of this study is to develop the protocol and testing feasibility and intensity of the Burn2Learn activities in college students, specifically comparing an exercise only (Gym) HIIT session and an exercise + cognitive activity (Brain) HIIT session. The Burn2Learn program was an intervention that was taught to teachers so they could administer to their students. It consists of various HIIT workouts including both aerobic and body weight resistance exercises followed by cognitive tests (14). It is hypothesized that the brain HIIT will have a positive acute effect on the cognitive functioning of the college students and that the protocol will be easily transferrable to all ages of children.

Methods

This research was a within-subject, crossover design where all participants completed both conditions: Gym HIIT and Brain HIIT. The intervention occurred on 2 separate days, about a week apart with each session lasting less than 30 minutes. To decide which session the participant completed first, a coin was flipped with heads being gym and tails being brain, so that it was randomized. The research participants consisted of 15 undergrad University of Arkansas students, 7 males and 8 females aged 20-22. They had to have medical clearance to participate in vigorous physical activity and not have any metabolic or endocrine diseases or be going through treatment for psychiatric disorders. All subjects participating in this study signed an informed consent form upon arrival for the first session and the study was approved by the University of Arkansas Institutional Review Board.

To analyze movement and physiological effects, participants were set up with Polar heart rate monitor on their chest, with the watch on their dominant wrist to display the heart rate. They were also set up with ActiGraph Link accelerometers on the non-dominant wrist and on the right hip. Participants then completed the mEMA cognitive assessments. developed by Dr. Jonathan Hakun from Penn State. We are collaborating with Dr. Hakun who leads a team that has been developing M2C2, an mEMA cognitive assessment for NIH Toolbox. We used the Symbol search, Dot memory, Color speed, and Go No Go tasks, brief 30 second to 2 minute working memory and cognitive control tasks to assess cognitive function. The participants' resting heart rate, height, and weight were then collected.

Participants then completed the assigned workout session. The sessions were titled "Gym HIIT 1" and "Brain HIIT 1", and participants were randomized to which session they completed on the first day. The participants first completed the warmup that included 15 seconds of jumping jacks, 15 seconds of lunges, 15 seconds of high knees running in place, and 15 seconds of mountain climbers. They then completed their designated HIIT workout that contained four 30 second intervals including 2 exercises each. There was a 30 second rest break between each interval. For the GYM session, the first interval consisted of 4 pushups coupled with a 10 meter shuttle sprint. After 30 seconds of rest, the participant began interval 2 that included 4 body weight squats coupled with 10 meter shuttle side steps. During the resting period after the 2nd interval, the halfway heart rate was measured. The third interval included 4 lunges followed by a 10 meter shuttle of high skips. Finally, the fourth interval after the 30 second rest was 4 sit-ups coupled with 10 jumping jacks. The final heart rate was then collected. The Brain HIIT session consisted of the same pattern, 30 seconds for each interval with a 30 second rest in between each one. Interval 1 was composed of a compass shuttle where the participant started in the middle of the compass and the technician called out a cardinal direction. The participant then sprinted 10 meters to the cone that represented the cardinal direction. The second interval included the participant sprinting forward 10 meters, and the technician then calling out left or right. The participant then ran to the proper cone, 8 meters away. The half way heart rate was collected during the rest break following the second interval. The third interval included the participant starting in the middle of 4 cones each 10 meters from the starting point. While in the middle, the participant was performing quick steps in place. The technician called out a direction (forward, backward, left, or right) and then the participant sprinted there and back, quick stepping in the center while waiting for the next direction to be called. The fourth interval consisted of the participant holding a front-support, push-up position with the feet in the middle of an imaginary clock. The technician called out an hour and the participant moved their hands to the appropriate position and then back to starting point at 12:00. The final heart rate was then collected.

Immediately following the HIIT session, participants took the mEMA cognitive assessments on the tablet again. Their monitors were removed and loaded onto the ActiGraph program, and then uploaded to Box to be assessed. The data from the mEMA will be used to determine the effects on working memory and cognitive control tasks. A repeated measures ANOVA will be used to detect a difference in the change of executive functions between the Gym HIIT and Brain HIIT conditions. We will also use this to compare the between-within interaction. Additionally, I used their physiological data and survey feedback to assess the difficulty and feasibility of this protocol.

Participants then came back about a week later to do the second session, either the Brain HIIT or the Gym HITT, whichever one they had not done yet. The same exact protocols were followed other than the specific exercises performed. Following the second survey, participants completed a Qualtrics survey identifying which session they preferred and why, what their favorite exercise was, and suggestions for improving the exercise session.

Results

A total of 15 participants completed both sessions, 8 females and 7 males. One participant, ID number 5, participated in the first session, but dropped out due to scheduling conflicts, so that subject's data is not included. The mean heights, weights, resting heart rates, mid-workout heart rates, post-workout heart rates, and times to complete the exercises are listed in the tables below. We also collected data from the accelerometers and from the cognitive brain tests, both found on Box in the ExCITE 2 folder under Data. The cognitive data is found in "Brain_Cog_Data" and "GYM_Cog_Data", respectively. The accelerometer data is found in the "Brain Accelerometer" and "GYM Acceleromter". The datasheets that were used to record the ID number, session, height, weight, starting time, ending time, time it took to complete the session, resting heart rate, mid-exercise heart rate, and post-exercise heart rates were scanned and also uploaded to their respective data sheet folders. The mean BMI for men was 24.75 and for women was 21.24.

Table 1: Mean data collected for each session

	Females		**Males**	
	Gym HIIT	***Brain HIIT***	***Gym HIIT***	***Brain HIIT***
Avg Time to complete Session	**7.4 min**	**8 min**	**7.3 min**	**7 min**
Resting HR	**79.75**	**75.875**	**82.14**	**79.43**

Mid-Session HR	**151.25**	**153.25**	**158.14**	**152.43**
Post-HR	**148.88**	**147**	**146.29**	**154.14**
%-HRR (intensity)	**61.88%**	**64.51%**	**64.99%**	**60.83%**

Following completion of both sessions, participants filled out a Qualtrics survey answering these questions: What is your first and last name? Which exercise session did you prefer- Gym or Brain? Why? What was your favorite exercise? Which was your least favorite? Would you participate in either session again? What suggestions do you have for improving the exercise session? The favorite session was pretty even with the brain session receiving 8 votes and the gym session receiving 7 votes. The participants who enjoyed the brain session more gave reasons including how fun it was, how the thinking distracted from the exercising, and how the tests were challenging in a good way. The participants who voted for the gym session all commented about how they enjoy exercising regularly. The most favorite exercises were running in the cardinal directions with 6 votes and the sit-up jumping jack bout with 5 votes. The general consensus about their least favorite exercise was the clock-plank bout with 6 votes and the pushup-running bout with 4 votes. A few participants commented about how they disliked running in general. The only suggestions given were potentially making the gym exercise more difficult or making the exercises longer with longer breaks.

<u>Discussion</u>

Collecting the data for both sessions went very well and ended up taking much less time than I expected. From the time it took for me to set up the equipment, the participant to take both tests and do the workout, until I finished uploading data and cleaning materials, it took a total of around 30 minutes. As far as time goes, I think the only thing to consider when working in the schools is remembering to factor in enough time to set them up with the accelerometers and heart rate monitors.

The heart rate data revealed that the intensities of the sessions were comparable. For each session and each gender, beats per minute never varied by more than a few digits and the percentages of heart rate reserve were also within about 4%. Post-exercise heart rate was always less than the mid-exercise heart rate, which could be explained both by the heart rate evening out as well as the intensity at the end decreasing slightly. For both sessions, the final bout no longer included running which another potential explanation for the decreased heart rate. The heart rate reserve intensities represented a moderate to vigorous exercise intensity, which is exactly what we were going for.

The HIIT activities were received well by the participants. Describing them using the pictures on the HIIT cards was very beneficial. Before the session I explained each one, demonstrating as needed, and then reminded them of what was next during the 30 second rest break. Participants expressed appreciation for the clear direction, so it is important to do the same in the schools. One issue I could foresee arising is the amount of space the activities take up. The gym session only needs about a 10 meter line. However, the distances we used during the brain HIIT (10 meters each direction) would most likely not be possible in a classroom setting. A larger space such as outside, in a gym, or in another open space would be necessary. A potential modification could be running in place and turning to face the direction that is called if there is no other option for extra space. It also depends on how many students are being tested at once. If it is an entire class performing these workouts, it would be nearly impossible to perform the brain HIIT section without space modifications.

The Qualtrics survey data gave decent insight on the reactions of the participants. The suggestions provided, including making the sessions more difficult or making the exercises longer, would not be applicable to the future study involving adolescents. The difficulty level seems appropriate, as well as the length of time if it is to be used intermittently throughout the school day. Ultimately, the immediate feedback and the data from the survey showed that the overall process is feasible and not overly challenging for college students, which I believe will translate smoothly to adolescents.

This entire research process has been extremely eye-opening to me. Since everything did not go as originally planned, the most important lesson I learned was how to be flexible and adaptable, traits that I learned are necessary in all research areas. I also learned how much work went on behind the scenes. I spent almost a whole school year preparing for just a few weeks of data collection, but all the prep time was vital to the success of the trials. Learning how to work the equipment, describe the exercises, and upload the data was something that took careful instruction and ample practice so that I could get it down. My suggestion for anyone working on this study is to get more than enough practice so every session runs as time-efficient and smooth as possible. Another major lesson I learned was the importance of consistency. By instructing every person in the exact same way, doing each step of the process in a specific order, giving the same encouragement, and letting them know when they were halfway through, I was able to ensure that there would be no confounding variables like confusion or distraction. Finally, I learned that research takes collaboration. I could not have done any of this without Bryce, Hannah, Andrew, and Dr. Howie, who were all there to help if I had a question or needed to bounce ideas off with someone. There are many moving parts in research, but as long as everyone performs their specific job, collaborates with the rest of the team, and stays open and flexible, the process runs smoothly.

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