Journal of Kinesiology and Wellness
A Publication of the Western Society for Kinesiology and Wellness
Volume 10, Number 1, Pages 73-84, 2021
ISSN# 2332-4503

EFFECTS OF PHYSICAL ACTIVITY CHOICE ON IMPLICIT LEARNING IN YOUNG ADULTS

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Submitted June 2021; Accepted in final form September 2021

Guerra, R., et. al. The effects of physical activity (PA) on implicit learning (IL) "learning complex information without awareness" are still uncertain. Many have hypothesized that aerobic PA benefits include maintaining and improving certain cognitive functions. The main objective of this study was to determine how PA level and activity choice influence IL in young adults. The study used twenty-four healthy college-aged adult participants. Participant's PA level was measured using the International Physical Activity Questionnaire-Long Form (IPAQ-LF), and IL was compared using the Triplets Learning Task (TLT). Participants were then placed into categories under IPAQ classifications. Moderate classification in PA for health benefits consists of meeting one of three criteria: (1) ≥ three d·wk-¹ of vigorous-intensity totaling 60 minutes (2) ≥ five d·wk-¹ of moderate-intensity ≥ 150 minutes or (3) ≥ five d·wk-¹ of any combination of walking, moderate-intensity, or vigorous-intensity activities totaling ≥ 600 MET-min·wk. The 4 choices of PA included (1) none (random activity), (2) resistance, (3) cardiovascular, or (4) a structured program plan. In this study, "learning" was defined by reaction time (RT) and accuracy compared to the median scores. Results from TLT indicated that PA level was statistically significant ($p < 0.05$) in explaining variance in the learning scores. In particular, participants who did PA of cardiovascular and resistance had faster response times and higher learning on the IL task than PA of low and random activity. In conclusion, the results suggest that moderate or vigorous PA assists in the improvement of IL.

Key Words: response time, implicit learning, IPAQ classification, preferred activity

INTRODUCTION

HealthCare costs are estimated to project an increase of $66 billion per year by 2030 by individuals not meeting PA participation requirements to receive health benefits (Wang et al., 2019). Until recently, IL appeared as a ubiquitous process in cognition. Individuals with cognitive disorders and Parkinson's diseases have shown IL's importance to motor function (Hayes et al., 2015).

As we age, the importance of cognitive function becomes vital to the aging process for daily living and disease prevention. Humans have the ability to maintain and improve physical health with the appropriate amounts of physical activity (PA) over our lifetime. In particular, the benefits of aerobic types of PA improves cardiovascular function. This type of activity reduces risk factors and decreases morbidity while maintaining and enhancing cognitive function. (Physical Activity Guidelines for Americans, 2nd Edition, n.d.). However, the effects of PA on implicit learning (IL), "learning complex information without awareness," are still unclear.

Physical activity guidelines recommend moderate to vigorous intensity activities most days of the week. The current study used PA to determine if participation level and activity choice affected IL. The study also looked at the type of PA choice compared

to PA choice on the Triplets Learning Task (TLT) performance, an implicit probabilistic sequence learning (IPSL) task. Reaction time represents the interval from the presentation of an unanticipated stimulus until the beginning of the response, as response time is the sum of reaction time plus movement time. Motor movement and functions endure in individuals with cognitive diseases (Arenberg, 1973; Dimmock & Banting, 2009; Duchesne et al., 2015; Schaefer & Schumacher, 2011).

The benefits of PA and explicit learning are well studied (Sexton et al., 2016). However, measuring IL has proven difficult. Several studies have examined IL by the effects of implicit sequence learning (ISL) to extract probabilistic regularities from sequences of events (Bennett et al., 2007; Howard et al., 2008; Howard Jr. & Howard, 1997; Simon et al., 2011a; Stillman et al., 2016).

The ability to transfer acquired knowledge is discreet and occurs through passive, incidental, and automatic acquisition. Limitations in early IL studies revealed findings to have structural tasks similar to explicit learning tasks. Recently, studies showed the robustness of IL through evidence from cognitive disorder findings (Konkel & Cohen, 2009; Reber, 2013; Rieckmann et al., 2010; Simon et al., 2011b; Stillman et al., 2016).

Participation in physical activity and physical fitness is commonly known to provide multiple benefits, such as improved brain health and cognitive function. During the past few decades, knowledge of procedural learning expanded (Ashby et al., 2003; Howard et al., 2008; Müller et al., 2016; Simonet al., 2011a; Stillman et al., 2016). However, these experiments mainly focus on explicit learning.

Our understanding continues to improve from a relatively simple learning mechanism explored through various experimental paradigms, including artificial grammar and motor learning. The valued outcome of IL involves how environmental stimuli affect motor behavior.

Moreover, the role of associative learning mechanisms exploits the same statistical dependencies within an environment to generate highly accurate knowledge and representations of IL. In other words, the environments we live in have an abundance of information we are unaware of affecting our behavior.

Given our sensitivity to routines and the ability to gain expertise, humans are adept at learning without intention (Simon et al., 2011b). However, humans can learn unintentionally attempted to fill in unknown information to complete unfamiliar or new tasks.

Physical activity and cognition literature require further stringent criteria as others have suggested (Hardwick et al., 2013; McAuley et al., 2013; Prakash et al., 2015). Refining and developing the categorization of PA is vital to distinguish any effects on IL. A study by Howard et al. (2008) resulted in a novel method using Triples Learning Task (TLT) where IL was compared with physical fitness. Improved cognition is one of many known and accepted benefits arising from cardiovascular fitness health (Mandolesi et al., 2018).

Studies using TLT have compared brain activation between perceptual and motor levels of ISL provided insight into hippocampal and caudate learning (Howard et al., 2008). Both young and aging adults enlist the hippocampus early. With training, younger adults can recruit their caudate, and older adults continue to rely on the hippocampus (Rieckmann et al., 2010; Simon, et al., 2011b). Physical activity is recognized to be beneficial for physical and cognitive function. However, the uncertainty regarding PA and IL warrants further research.

The purpose of this study was to understand the cognitive benefits related to PA by using the International Physical Activity Questionnaire-Long Form (IPAQ-LF) assessment with choice of activity and comparing IL using the TLT. Using PA guideline levels and type will identify any influences that may occur in IL. The recommended PA for adults aged 18-65 years for health benefits should accumulate a minimum of 30-60 minutes of moderate-intensity aerobic activity five days per week or 20-60 minutes of vigorous-intensity three days per week (Haskell et al., 2007). The present study attempted to expand IL's current understanding by categorizing PA by IPAQ scores and the preferred activity method in healthy young adults. The overall objective was to determine if the types of PA improve IL differently. The first specific aim was to determine whether PA level would induce differences in IL. The second specific aim was to

determine if PA choice would affect IL in young adults. We hypothesized that PA level is directly related to higher IL, and choice in cardiovascular PA is directly associated with greater IL.

RESEARCH METHOD

Participants

This study obtained approval from the Indiana University Institutional Review Board. Each participant was provided with an informed consent before data collection. Twenty-four participants completed a PA assessment and health questionnaires. Each participants' PA level was measured using the IPAQ-LF (ACSM, 2014). The type of PA choice participation was self-reported. According to IPAQ-LF, participants are categorized as low, moderate, or vigorous based on their current health guidelines. The International Physical Activity Questionnaire-Long Form IPAQ-LF classification of sedentarism requires individuals not meeting the moderate or high criteria. The participants were then placed into categories under the IPAQ classifications. Moderate classification in PA used for health benefits consists of meeting one of three criteria, "(1) ≥ three days per week ($d \cdot wk^{-1}$) of vigorous-intensity totaling 60 minutes (2) ≥ five ($d \cdot wk^{-1}$) of moderate-intensity ≥ 150 minutes or (3) ≥ five ($d \cdot wk^{-1}$) of any combination of walking, moderate-intensity, or vigorous-intensity activities totaling ≥ 600 metabolic equivalent of task (MET) of minutes per week ($min \cdot wk^{-1}$)." Included was the self-reported type of PA participants engaged in (1) none (random activity), (2) resistance, (3) cardiovascular, or (4) a structured program plan.

Inclusionary Criteria

Participants were placed in groups based on self-reported preferred PA regarding the current activity type they regularly participate in at present. The activity choice type was either none or random activity, cardiovascular, resistance, or a structured program plan. Based on the IPAQ-LF results, participants were placed in low, moderate, or high categories based on PA's measurement and history of the past seven days. There are also less stringent than fitness assessments such as VO2 max and submaxim testing. Fitness assessments measure fitness levels at the moment in time. It was more appropriate for the current study seeking PA benefits and had repeatedly been used in similar studies when using PA comparisons.

Exclusionary Criteria

Each participant was screened for any history of orthopedic injury, musculoskeletal, vestibular, neurological disorders, or stroke. Cognitive functions were assessed using the Mini-Mental State Exam. With a required score above 20 on a 30 maximum point scoring system. If unable to complete or incorrectly, the individual's data will be removed from the analysis.

Research Design

We are expanding current methods by controlling and categorizing the PA level and history to determine if IL is affected by an individual's activity behavior. Knowing PA history will assist in identifying behavioral influences affecting IL. Recommended PA for adults 18-65 years is to accumulate a minimum of 30-60 minutes of moderate-intensity aerobic activity five days per week or vigorous-intensity for at least 20-25 minutes on three more days a week (Haskell et al., 2007). Using these criteria to determine physical activity and preference in either cardiovascular or resistance activity will establish more stringent standards for any effects of IL in young adults.

Our IL method begins by adapting TLT, a method developed to measure IL and IPSL. Triplets learning task was responsive to individual differences in striatal function (Simon et al., 2011b). The striatal function is essential because it plays a role in decision-making and judgment (Hjorth et al., 2020). Using the TLT allows examining the relationship between probabilities and speed/accuracy both within and across individuals. Such information could also be used for developing reliable intelligence tests. In contrast with the traditional statistical learning task (SLT), TLT requires a response on every trial allowing for online performance-based learning measurement, rather than explicit judgments or random guessing in a continuous test.

Instrumentation

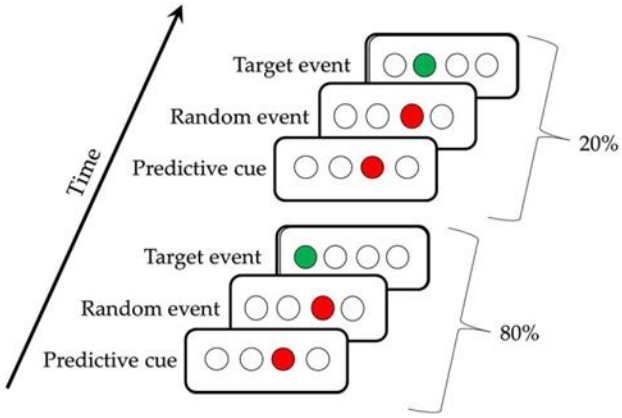
Demographics. Demographic variables obtained include age and gender. Participants answered

questions regarding possible physical or cognitive disabilities, injury or impairments, and physical activity history.

Implicit Probabilistic Sequence Learning. Implicit probabilistic sequence learning IPSL was assessed using TLT, a four-choice response time ISL task. A "triplet" is a three-event sequence of open circles filled sequentially with red, red, and green, as seen in Figure 1.

Figure 1

Triplets Learning Task schematic



Participants were directed to observe the first two red events without responding, then correspond to the green target's final sequential location by pressing the spatially corresponding key number 1-4. The color cues are displayed one after the other for 120ms each (150ms inter-stimulus interval) and followed by the target 150ms later, which remains in view until participants make a response ending a single trial. The timing of consecutive events reduces potential bias in overall speed differences (e.g., speed-accuracy tradeoffs). Participants were unaware of the regularities in the task and were encouraged to respond as quickly as possible to the green targets. The next trial began 650ms after the participant responded to the target.

TLT contains a probabilistic regularity represented by the location of the first red cue, probabilistically predicting the target location. The location of the second red cue is random. Participants completed two 500-trial sessions of TLT and a total of 1000 trials to prevent fatigue. The second session also reduced the potential bias of individual differences in overall speed.

Intermittent feedback was displayed every 50 trials; participants were told to either "focus on speed," "focus on accuracy," or the "response is about right." Participants were unaware that the feedback message is based on the individual's accuracy on the proceeding 50 trials and designed to guide all participants to respond with a similar error rate per session.

As mentioned previously, the TLT contains a probabilistic pattern unknown to participants. Targets appear in high probability (HP) locations and follow the predictive cue on 80% of trials. The other 20% of the same red cue follows the target, resulting in three low probability (LP) locations. Since 64 triplets are possible, 16 triplets occurred with HP of 80% frequency, appearing 15-40 times per 500 trials, while 48 triplets appear 1-8 times per 500 trials at LP of 20% frequency. The HP triplets are not determined randomly. Triplets Learning Task assigns each participant to view triplet sequences following one of 6 possible patterns. The pattern of numbers corresponds to the predictive (first) cue and target (Stillman et al., 2016).

Physical Activity. International Physical Activity Questionnaire-Long Form IPAQ-LF was used to measure participants' PA. The IPAQ-LF is a self-report survey of PA over the past seven days structured to provide separate domain-specific scores for walking, moderate and vigorous-intensity, work, transportation activities, domestic chores, gardening, and leisure-time domains.

The IPAQ-LF classification PA score requires the summation of minutes and frequency of days for all types of domain activities or specific sub-scores. Domain-specific scores are individual for walking, moderate-intensity, and vigorous-intensity activities. However, some particular scores require the summation of scores for all types of activity across all domains. Additionally, participants self-reported the engagement in either resistance, cardiovascular, or both in a structured program plan.

Procedures. Data collected was from young college-aged adults aged 18 and 22 and conducted testing and data collection at Indiana University's Cognitive Neuromotor Control Laboratory. The

research team scheduled participants on availability dates. All researchers underwent training for human subjects through the Indiana University Institutional Review Board.

Participants were instructed to complete the demographic questionnaire, health pre-screening, the Mini-Mental State Exam, and the IPAQ-LF. Completion of questionnaires, screenings, and surveys took approximately 20 minutes. Participants completed the TLT individually on a laptop, which took about 30 minutes with a single break between sessions one and two to prevent fatigue.

Participants were instructed to complete the TLT, an IPSL task in which they correctly identify where the stimulus, a green filled-in circle, would appear. The location three-event sequence of varied stimuli among four possible locations across trials requires a single keypress. The researcher explained that the number of keys represents the four circles corresponding to the screen's displayed circles. Beginning the next trial requires a keypress. After each 50-trial block, prompt performance feedback with directions on the screen allowed a short break for feedback. When the individual is ready to continue, the spacebar is pressed. After the TLT test, the program ended automatically with a thank you for completion message. The total time for completion was approximately 45-60 minutes for each participant that completed the study.

Triplets Learning Task Data Analysis. All statistical analyses were conducted using R. The statistical analysis involved descriptive statistics and multiple regression analyses in examining IL related to PA level and choice of activity. This study used TLT mean reaction time differences between sequence and random trials to measure implicit learning. Faster RT on sequence trials versus random trials indicated IL had occurred. Before analysis, variables were tested for normality.

Measures of Sequence Learning. Measuring TLT sequence learning by comparing response times to HP and LP triplets was quantified using the present study's two measures (Howard et al., 2008).

Implicit Associative Learning Scores. In the IAL scores measure, the average RT on the random trials is subtracted from the average RT on the sequence trials relative to the RT on the random trials. As in previous studies, the TLT quantified learning by calculating IAL scores to measure unbiased learning by individual differences in overall reaction (Stillman et al., 2016). Lower negative values indicated greater IL ([(sequence trials – random trials)/random trials] x 100). Positive values indicated that the average RT for sequence trials was longer than the average RT for random trials, indicating a lack of IL. Physical activity levels and choice of activity group scores were compared, and any possible interactions were utilized using multiple regression analyses. The TLT contains all possible triplets and their probabilistic designations in each of the six possible patterns. The design ensures counterbalanced cue-target relationships across participants, and all possible target locations occurred equally often, eliminating the possibility of target frequency-based learning. Each triplet calculation of IAL is scored by mean reaction time for all accurate responses to each triplet then correlated with the number of instances the triplet appeared during each session. Individuals with strong negative correlations between reaction time and triplet frequency reveal they gained sequence-specific learning. They respond faster to triplets occurring with greater frequency. Before inferential analyses, correlations were multiplied by -1 to reflect greater IAL (Stillman et al., 2016). Implicit associative learning IAL scores for each participant were calculated for each session of 500 trials of TLT (Howard et al., 2008).

By subtracting each participant's mean HP reaction time to LP, triplets will determine difference scores and the triplet type effect size. The more substantial the difference scores are, the more learning is assumed to be happening.

To assess whether learning is implicit, participants completed a computer-based recognition task immediately following TLT. Participants saw all 64 possible triplets, then rated how often each triplet occurs. The two red cues and target presentation timing are the same as other TLT studies (Howard et al., 2008; Simon et al., 2011b; Stillman et al., 2016). Accuracy was also used to measure learning. Unfortunately, it is difficult to detect a difference between HP and LP conditions when accuracy is high. Accuracy-based scores are a

less sensitive measurement of learning than RT-based measures in the TLT (Chiviacowsky & Drews, 2016).

RESULTS

Learning Results

Behavioral learning results were obtained using TLT means and medians of the correct response scores from RT and accuracy influencing the relationship between PA and IL in young adults.

Paired t-tests determined "learning" between the median and mean accuracy for trial session 1 vs. trial session 2. Learning was tested by RT between the trials concerning median or mean RT between trials. The t-statistic, trial session 1 vs. trial session 2, shows a significant difference in median RT between the two session trials $t(21) = 4.22$, $p = .004$. The sample mean of the differences is 30.52. The median RTs in trial 1 were about 30 ms slower than those in trial 2. Paired *t*-test for trial session 1 means accuracy and trial session 2 mean accuracy shows similar results between mean accuracy of the two trials $t(21) = 3.69$, $p = .01$. The sample mean of the differences was 38.47. The test of mean accuracy RTs gave similar results.

Physical Activity Results

The IPAQ-LF classification for individuals to achieve PA health benefits by attaining a minimum total of at least 1500 MET-min·wk^{-1} or seven days of any mixture of walking or vigorous-intense activities of a minimum total of at least 3000 MET- min·wk-^{1}. Half of the study's participants were categorized as moderate activity (11 out of 22) based on IPAQ-LF scores.

Self-reported participation revealed that individuals who participated in moderate activity levels most days of the week were significant ($p < 0.05$). Of the 22 participants who preferred specific activity, six engaged in random physical activity behavior with no activity preference. Most participants self-reported, category 3, cardiovascular activity. Two participants engaged in only the resistance type of PA. Five participants reported their behavior of a structured program plan involving both resistance and cardiovascular activity.

Histograms

The distribution in Figure 2 shows the difference of mean accuracy by triplet type in trial 1, which is skewed to the left. One subject had a mean accurate reaction time that was much lower than the rest of the group.

Figure 2

Differences in mean accurate reaction time by triplet type (high – low) for trial 1

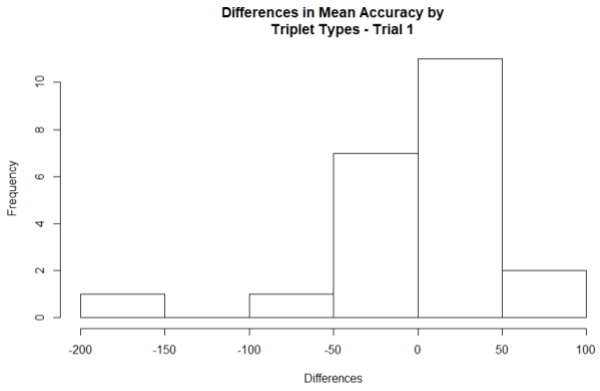
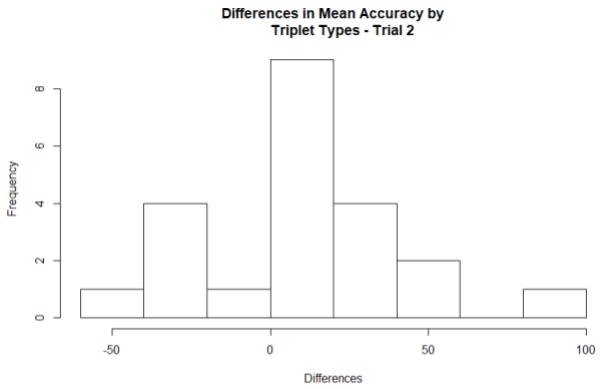


Figure 3

Differences in mean accurate reaction time by triplet type (high – low) for trial 2



In Figure 3, the distribution of mean accurate reaction time by triplet type in trial 2 is approximately normally distributed. Because of this, significant difference ($p < 0.05$) in mean accurate reaction time among participants indicating learning. Most participants had a mean response time between 1000-1100 milliseconds, with an outlier in the 600-700 range.

Boxplots

Figure 4 shows a significant amount of overlap, which implies unlikeliness to detect a difference in the number of correct responses by the IPAQ classification. One member of the moderate group had a much lower number of correct responses relative to the rest of the subjects both in the moderate group and overall. Figure 5. there is a significant amount of overlap between the high and moderate IPAQ groups regarding mean reaction time. Figure 6 shows that the cardio and structured program plan groups have a much larger number of correct answers overall compared to the resistance and no preference groups. The two members of the resistance group achieved the same number of correct responses. Figure 7 shows that the cardio and structured program plan groups tend to have longer response times than the no preference and resistance groups. The low-scoring subject from the previous plots is a member of the no preference group. Figure 6 and Figure 7 indicate that cardiovascular and resistance activity have faster reaction times and learning by the IL task.

Figure 4

Correct Responses by IPAQ Classification

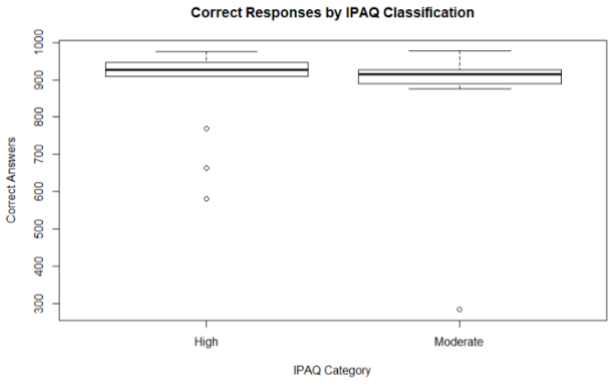


Figure 5

Mean Reaction Time by IPAQ Classification

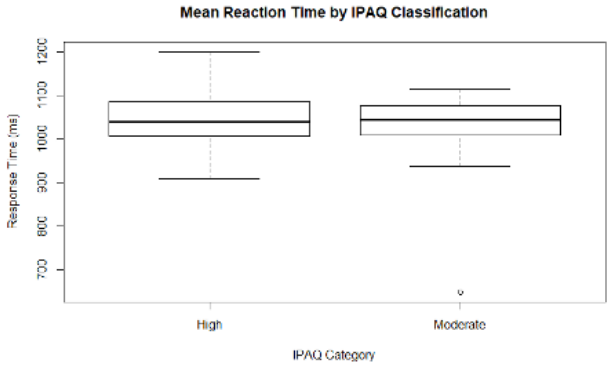


Figure 6

Correct Responses by Activity Type

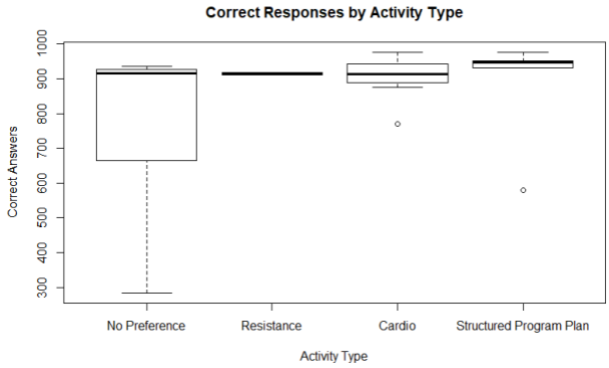
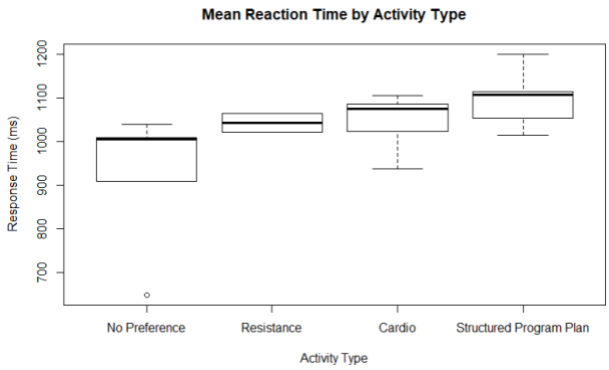


Figure 7

Mean Reaction Time by Activity Type



Regression Results

Regression Mean results for RT in PA type are shown in Table 1.

Table 1

Results of Regression of Mean RT by physical activity type.

Coefficients	Estimate	Standard Error	t-value	p-value
Intercept	935.81	37.97	24.646	< 0.001
Resistance	107.25	75.94	1.412	0.1749
Cardio	110.15	49.02	2.247	0.0374
Structured PP	161.80	56.32	2.873	0.0101
Residual standard error: 93.01 (df = 18)			Adjusted R-squared: 0.2246	

The means show statistically significant evidence of a difference in mean reaction time when switching from the intercept "no preference" group to the "cardio" group ($t(18) = 2.247$, $p = 0.0374$) as well as when switching from the "no preference" group to the "structured program plan" group ($t(18) = 2.873$, $p = 0.0101$). This difference results in a predicted increase in mean reaction time by about 110.15 ms for the "cardio" group and about 161.80 ms for the "structured program plan" group.

Mean response time did not differ between IPAQ classification and self-reported groups. Participants in the cardio and structured program plan activity type had significantly greater correct answers than participants in no preference and resistance groups.

Regressions for Mean RT for IPAQ, PA type, and gender are shown in Table 2.

Table 2

Regression Mean RT for PA Choice Type and Gender (f = 14, m = 10)

Coefficients	Estimate	Standard Error	t-value	p-value
(Intercept)	928.76	45.31	20.496	2e-13 ***
Resistance	100.2	81.29	1.233	0.2345
Cardio	114.06	51.92	2.197	0.0422*
Program plan	163.21	57.98	2.815	0.0119*
Male	14.1	46.27	0.305	0.7642

Table 3

Regression for Physical Activity Classification and Self-reported Results

Coefficients	Estimate	Standard Error	t-value	p-value
(Intercept)	866.56	70.48	12.295	6.94e-10 ***
Moderate	182.03	77.92	2.336	0.0320 *
Vigorous	229.17	99.68	2.299	0.0344 *
Residual standard error: 99.68 (df = 17)			Adjusted R-squared: 0.1094	

Self-reported	Estimate	Standard Error	t-value	p-value
(Intercept)	865.15	51.05	16.948	3.42e-11 ***
Resistance	36.59	80.71	0.453	0.65678
Cardio	191.82	61.01	3.144	0.00669 **
Structured PP	257.38	72.19	3.565	0.00282 **
Residual standard error: 88.42 (df = 15)			Adjusted R-squared: 0.07073	

In all models, there was no evidence of a statistically significant effect of change of IPAQ level from "high" to "moderate" or from "female" to "male." However, in these models, there was a statistical difference when moving from the intercept "no preference" group to the "cardio" and the "structured program plan" group. The slope for self-reported moderate activity was significant ($p < 0.05$). Individuals reporting vigorous activity on most days of the week and the cardiovascular activity group with structured program plan were significant.

DISCUSSION AND CONCLUSION

Discussion

While learning was still captured, the initial intent was to use Triplets Learning Task. Overall the results from the study provided support regarding the benefits of physical activity. Because of the removal of two participants at the analysis stage, learning was tested by response time between the trials concerning median or mean reaction time. Results supported reaction time and response time findings in the literature. It was identified that participants who favorably chose cardiovascular PA and planned PA learning scores improved than resistance and no planned activity groups.

The participants with IPAQ classification as moderate had significantly greater correct answers than those with low IPAQ classification. Those with IPAQ classifications, moderate and vigorous, had improved response times reflecting learning than individuals not meeting IPAQ moderate category and preferred random PA. Participants self-reportedly preferred type 3 cardiovascular PA reflecting potential behavioral adherence in conjunction with the individual's history of PA classified in the IPAQ questionnaire. IPAQ revealed that most of half of the study's participants were classified as moderate activity. At the same time, the most substantial portion of self-reported preferred PA identified with a cardiovascular type of physical activity.

Responses between IPAQ high (vigorous) and moderate have a significant amount of overlap, which implies unlikeliness to detect a difference in the number of correct responses by the IPAQ group. The cardiovascular and structured program plan groups tend to have longer response times than the no preference and resistance groups. The self-reported cardio and the structured program plan groups had significantly greater correct answers than participants with no preference in PA. One member of the moderate group had a much lower number of correct responses relative to the rest of the subjects both in the moderate group and overall. Most participants (14 out of 22) had a mean response time between 1000-1100 milliseconds. Learning of the designated TLT pattern occurred between 1000-1100 ms as this indicates stimuli identification, information processing, then executing the motor movement.

Trial session 1 vs. trial session 2 shows a significant difference in median reaction time between the two session trials. The median reaction times in trial 1 were about 30 ms slower than those in trial 2, evidence of processing and learning. The decrease in median reaction time indicated that learning had occurred. There is a significant overlap between the "high" and "moderate" IPAQ groups involving mean reaction time. The "low" group had a much higher level of variability than the "moderate" and "vigorous" groups. Any differences in mean reaction time should be viewed with hesitation due to the small sample size in this group and the fact that the subject with the lowest overall reaction time was one of the two subjects in this group.

The mean reaction time and responses by PA type concludes that the mean reaction time of the cardio and structured program plan groups are slower than the no preference and resistance groups. Those who

participate in cardio have higher implicit learning scores and thus faster mean reaction times than those who participate in other physical activities. Results agree with the literature that moderate PA levels can benefit health and learning.

Conclusion

This study examined the relation between PA and IL in young adults to expand current knowledge of PA benefits and the effects of brain cognition during aging. Physical activity levels and preferred activity choices throughout our life influence cognition and quality of life. Regular PA participation over a lifetime or a significant portion is known to contribute to health-related benefits. Exploring PA and cognition findings can improve the quality of life in individuals by better understanding the history of PA participation.

Interestingly, nine of the twenty-two participants self-reported category 3 type activity, cardiovascular training. In other words, 40% of participants achieved health benefits. Conversely, 60% of other participants did not meet the health benefit. This study results suggest that those who benefit from PA through cardio and structured program plan responses rely on cognition and correctness rather than reaction time. Suggesting those from no preference and resistance groups are concerned with the speed of execution. Including those who benefit from PA, suggesting the cardiovascular and structured program plan groups have possible behavior tendency of their responses rely on cognition and correctness rather than reaction time. Meaning those from no preference and resistance groups are concerned with the speed of execution than correctness.

Each of these groups which met the IPAQ's required moderate activity gained benefits from their participation in PA. Physiological and cognitive, possibly resulting in more significant correct responses. Physical activity choice in this study reflects the known benefits of participating in PA. It was identified that participants who favorably chose cardiovascular workouts and planned workouts scored better than resistance and no planned activity. Supporting that PA benefits cognition and suggesting further study with larger participant groups to explore implicit learning and PA behavior for improving quality in life during the aging process.

ACKNOWLEDGEMENTS

N/A

FUNDING

N/A

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