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Impact of Physical Activity on Learning Multi-Word Expressions and Improving Positive Affect in a Foreign Language Context

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ABSTRACT

The positive effect movement has on physical health and wellbeing is well established, yet how it affects cognitive processes such as attention, memory, and creativity has recently attracted growing research interest. The study presented here was designed as an exploratory investigation to examine the effect movement had on memory retention for a set of 20 multi-word expressions (e.g. idioms) among English as a Foreign Language (EFL) learners and how it impacted their affective states. Using a randomised controlled trial with a mixed-design structure, 32 participants either sat and read a graded reader or walked on a treadmill for 20 minutes prior to a learning session. Data from immediate and delayed posttests and pre- and post-PANAS questionnaires were analysed. Results show that movement enhanced learning on both tests and improved positive affect, whereas no differences were found for negative affect. Fitness level was included as a covariate but did not account for the observed group differences. Pedagogical implications of this research are discussed within an embodied learning framework, highlighting the role the body plays in cognitive processes, particularly memory.
Keywords: Physical activity, exercise, memory, cognition, learning, multiword expressions, EFL

1. INTRODUCTION

Physical activity (PA) refers to "any bodily movement produced by skeletal muscles that requires energy expenditure" (World Health Organization, 2010, p. 53). The health benefits are well documented, as PA is associated with wide-ranging health benefits, from reduced all-cause mortality (Löllgen et al., 2009) and improved cardiovascular health (Myers, 2003) to lower risks of various types of cancers (Liu et al., 2016). Besides the health benefits, PA also has a positive impact on the individual's mental health, protecting one against depression (Kvam et al., 2016) and enhancing wellbeing (Herbert, 2022). This includes enhancing positive affect (Birdsell, 2023; Bourke et al., 2024). For example, in a study using an ecological momentary design where university students were monitored over one full week, researchers found that replacing sedentary time with moderate-to-vigorous intensity PA was associated with more positive affective valence (Bourke et al., 2024). Birdsell (2023), using a within-subject design study where participants performed both a sitting/reading and treadmill walking condition, found that after walking, participants statistically scored higher for positive affect.

Additionally, converging evidence suggests several cognitive benefits of PA. These benefits can even occur from a single bout of PA, which has been shown to improve working memory and cognitive flexibility in preadolescent children and older adults (Ludyga et al., 2016). Furthermore, a meta-review using 30 systematic reviews with meta analyses concluded that acute exercise facilitates cognitive function across various cognitive domains, regardless of individual characteristics (Chang et al., 2025). The mechanisms why PA might support various cognitive functions such as memory retention are still not fully understood, but likely include increased blood flow to the brain, release of brain-derived neurotrophic factor (BDNF), which supports neuronal growth, and stronger connectivity between brain networks (Winter et al., 2007). Moreover, acute PA elevates arousal and attentional resources prior to the learning session, which then may enhance encoding (Lambourne & Tomporowski, 2010). Some research also suggests that acute PA supports memory consolidation (Roig et al., 2013), which may partly explain gains observed on delayed posttests. For example, consistent with this, Hötting and colleagues (2016) found memory gains for recalled words after 24 hours for participants in the exercise group, compared to the relaxing group.

Despite these findings, few studies have examined memory gains for foreign (second) language (L2) vocabulary following acute exercise. This gap is important given that L2 learners represent a significant portion of the global population, as estimates of English L2 speakers alone number over 1 billion. L2 vocabulary learning is a demanding cognitive task, requiring learners to encode meaning, phonological form, and, for multiword expressions, grammatical order. Currently, most PA and memory research has been conducted with L1 speakers and findings may not be generalisable to L2 learners, as they face distinct cognitive challenges from reduced linguistic exposure to higher levels of cognitive load. The present exploratory study aims to address this gap by providing preliminary evidence on the effects of PA on vocabulary retention and beginning a discussion on the broader impact of PA on language learning.

This study refines and extends Birdsell's previous research (2023), which examined EFL learners' vocabulary gains using a within-subject design, comparing a short bout of exercise with a sitting and reading condition across two sessions, each followed by a learning intervention with pre–post and delayed posttests. Results showed a statistically small improvement after the exercise condition, as measured by the delayed posttest. Students also reported significantly higher positive affect after the exercise condition compared to after the sitting condition. Two limitations of Birdsell (2023) were variability in participants' prior knowledge of the target vocabulary and the absence of covariates. The present study addresses these limitations by using multi-word expressions (MWEs, e.g. idioms) as target items, which had a levelling effect since the MWEs were selected to be unfamiliar to all participants, and by including fitness level as a covariate.

Multi-word expressions are commonly defined as "lexical items which consist of more than one 'word' and have some kind of unitary semantic or pragmatic function" (Moon, 2015, p. 120). This can include phrasal verbs (e.g. 'break out', 'break in'), idiomatic expressions (e.g. 'a piece of cake'), and collocations (e.g. 'at risk', 'under pressure'). For L2 learners, MWEs are difficult to acquire because (1) they are often opaque, non-literal, and difficult to interpret from the compositional parts; (2) they are numerous in the language, but not widely taught in EFL textbooks; (3) learners often experience first language (L1) interference by way of misleading translations; and (4) as fixed or semi-fixed lexical bundles, learners must memorise and recall the entire expression as a unit, which poses a significant challenge. Given these challenges, the MWEs were selected as the target items for the learning session, as they provide a theoretically motivated means of examining memory in EFL learners. Additionally, fitness level was included as a covariate because individuals differ considerably in their habitual physical activity levels, which may confound the cognitive benefits of PA.

2. METHODS

This exploratory study investigates the impact of PA on EFL learners' acquisition of MWEs, as measured by immediate and delayed posttests, comparing a short bout of exercise to a seated reading condition. The study addresses the following research questions:

- RQ1: Does a short bout of physical activity before learning a set of MWEs enhance their acquisition, as measured by immediate and delayed posttests?
- RQ2: Does a short bout of physical activity improve positive affect compared to a seated reading condition?
- RQ3: To what extent does fitness level explain MWE acquisition and retention outcomes across the conditions (walking vs. sitting)?

Participants

Given the exploratory nature of this study, a formal power calculation was not conducted. However, a sample of 32 participants is consistent with comparable studies examining the effects of acute PA on vocabulary learning (Hötting et al., 2016; Schmidt-Kassow et al., 2014) and is deemed sufficient to generate preliminary effect size estimates to inform future research. The participants were Japanese university students (M_{age} = 19, SD = 1.8; 23 females) with Japanese as their first language (L1) and all of them had studied English (L2) for a minimum of six years in primary and secondary schools and one year at university. They came from various faculties and were recruited through flyers, posters, and online materials. There were no exclusion criteria for participation in this study. The student participants received remuneration for participating in the study based on the university guidelines.

Research instruments

To design test material for this study, the MWEs were first selected from books, online materials, and the author's own knowledge of the language. Then two research assistants who were L1 Japanese speakers with advanced English proficiency read through the list marking MWEs they were familiar with. These expressions were removed from the list, resulting in a final list of 20-items. The goal was to find MWEs that Japanese students are likely unfamiliar with and use these in the learning intervention as a flat starting baseline for all the participants.

For the 20-item MWEs test, the participants were presented with an MWE in a sentence. The MWE only had the first letter showing for each word and at the end of the sentence, a 'hint' was provided. Below is an example for the MWE 'in hot water'. These items were only in English, the L2 of the participants, and appeared in random order. The 20 items were aggregated resulting in a single score for each individual on both the immediate and delayed posttests.

- He's i ______ h ______ w ______ with his boss for missing the deadline. (Hint: This phrase means to be in trouble or facing consequences)

In the learning intervention, participants viewed a PowerPoint designed instructional video about the 20-item MWEs. Each MWE had its own slide with a linguistic explanation of its meaning, a visual image representing its meaning, and an example sentence. Each slide also had a Japanese translation for the text. Each slide in the video lasted roughly 25–30 seconds, so in total the learning intervention was roughly 10 minutes. This was a passive learning session where participants did not have any opportunity to practice or review the items. Additionally, at the start, there were four slides that provided the participants a quick explanation of the MWEs, one example, and an explanation of the instructional video.

The PANAS (Positive And Negative Affect Schedule) is a widely used and psychometrically validated self-report measure consisting of 20 mood related adjectives, 10 reflecting positive affect (e.g. enthusiastic, interested) and 10 reflecting negative affect (e.g. distressed, afraid), where participants rate the degree to which each is felt at a given moment (Watson et al., 1988). Given that participants in the present study were Japanese EFL learners, the Japanese version of the PANAS, validated by Kawahito et al. (2011), was administered at the start of the research and after the intervention to measure changes in the affective states. For the present study, six items from the original scale were removed (proud, jittery, upset, guilty, hostile, and alert) on the grounds that they were unlikely to be meaningfully influenced by the experimental manipulation (e.g. sitting or a short bout of treadmill walking). Items such as proud and guilty reflect self-evaluative emotions that are more likely to be influenced by achievement or moral contexts than by PA, while jittery was judged to overlap conceptually with anxiety terms already captured in the negative affect scale. This approach is consistent with the expectation that the measure can be adapted for specific contexts. The six items removed were replaced with eight new items intended to capture low-arousal states and a broader emotional range. This resulted in a 22-item scale with eleven positive and eleven negative affect items. To verify that the modified instrument retained the original two-factor structure, an exploratory factor analysis (EFA, principal axis factoring with oblimin rotation) was conducted. Sampling adequacy was confirmed (KMO = .81), and Bartlett's Test of Sphericity was significant, $\chi^2(231) = 1,074.06$, $p < .001$. Despite the modest sample size, the EFA yielded a clear two-factor solution consistent with the original PANAS structure. All positive affect items loaded on Factor 1 (.67–.87), and negative affect items loaded on Factor 2 (.45–.90), with no substantial cross-loadings, indicating a clear and stable factor structure. Three items with weaker loadings were retained as they remained above the conventional threshold of .40. Internal consistency was excellent for Positive Affect (α = .94) and good for Negative Affect (α = .85). These results are consistent with research indicating that strong loadings and well-defined factors can yield reliable EFA results even with small samples (MacCallum et al., 1999). Participants rated how well each item described their current mood using a 6-point Likert scale ranging from 1 ('I don't feel this way at all') to 6 ('I strongly feel this way'), presented in Japanese in random order. A 6-point scale was used to eliminate the neutral midpoint and encourage participants to select a more definitive response. Responses were summed separately for positive and negative affect items to produce two composite scores for each participant.

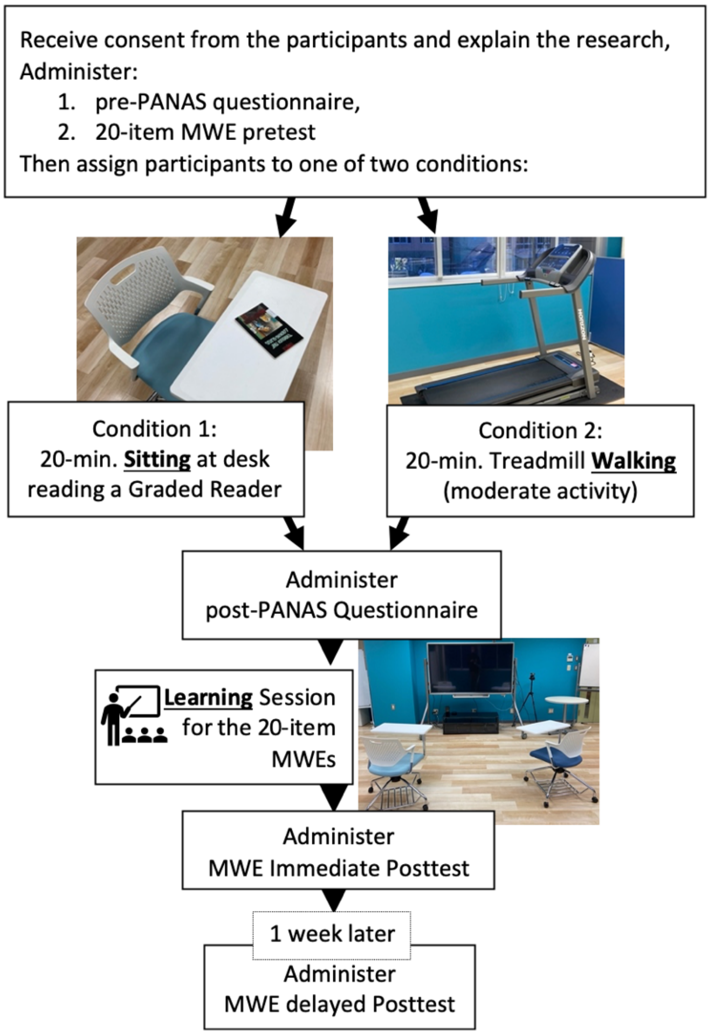
When student participants registered to participate in this study, using a Google Form, they completed a short 3-item survey of their fitness level. Question 1 asked about the number of times per week on average they exercised on an 8-point scale ranging from 'never' to '7 days a week'. Question 2 asked them how many hours per week on average they exercised on a 6-point scale ranging from 'less than 1 hour' to 'over 5 hours'. The third question asked them to rate their overall fitness level on a 5-point scale ranging from 'not at all fit' to 'very fit'. Each question was provided a numerical value based on the scale and then aggregated for a total fitness level score.

Procedure

Participants first completed an online survey indicating their interest in joining this research. Part of this online survey included self-report questions about their L2 level and fitness level. It also asked them to select a scheduled time to complete the research. Based on this schedule, participants came to the research room where the experiment was being conducted in pairs, groups of three, or individually for a 1.5 hour session. During this session, they first signed a consent form outlining the research. Then, they completed a pre-PANAS questionnaire. Next, they completed a 20-item MWEs pretest. It was included as a precautionary check to confirm baseline equivalence among the participants. As a result, all participants effectively began with the same baseline knowledge of the MWEs, allowing for a clearer assessment of learning gains. Student participants were recruited to join this study during the following four time periods: January 2025 (N = 9), April–May 2025 (N = 9), June–July 2025 (N = 6), and October–November 2025 (N = 8). This occurred because for each recruitment, only a limited number of students signed up and for each research session only one participant could use the treadmill.

The present study used a randomised controlled trial with a mixed-design structure. Participants were randomly assigned to either a control group (Condition 1, n = 16) where they sat and read a graded reader for 20 minutes, or an experimental group (Condition 2, n = 16) where they walked on a treadmill for 20-minutes. Immediately afterwards, the participants took a post-PANAS questionnaire. Both groups then participated in a learning intervention consisting of an instructional video on the 20-item MWEs. Following the instructional video, they completed an MWE immediate posttest. One week later, they completed an MWE delayed posttest (See Figure 1 for a schematic representation of this process).

Figure 1. **A schematic representation of the research procedure**



3. RESULTS

The learning condition (walking vs. sitting) served as the independent variable. The dependent variable was MWE test performance, measured at two within-subject time points: immediate posttest and delayed posttest. The pre-PANAS and post-PANAS questionnaire was used to measure the effect the condition (walking vs. sitting) had on positive and negative affect. Additionally, fitness levels were included as covariates.

All analyses were conducted using IBM SPSS Statistics (v. 30.0). First, a t-test was used to examine whether there were any differences in fitness levels and L2 level between the two groups. A preliminary independent samples t-test revealed no significant baseline differences in fitness levels between the walking and sitting conditions, $t(30) = -0.05$, $p = .96$. Nevertheless, fitness level was retained as a covariate in subsequent analyses given the possible relationship between habitual physical activity and cognitive benefits. As for L2 levels, participants primarily self-evaluated as being at the intermediate level. Table 1 provides descriptive statistics for the MWE posttests and results from the pre-PANAS and post-PANAS questionnaire for each of the two conditions.

Table 1. **Descriptive statistics for MWE posttests by condition, positive affect, and negative affect**

	MWE Posttests		Positive Affect		Negative Affect	
Condition	*Immediate*	*Delayed*	*Pre*	*Post*	*Pre*	*Post*
Walking	13.56 (4.24)	10.37 (4.66)	39.81 (10.09)	47.88 (9.77)	21.44 (8.30)	17.06 (7.11)
Sitting	10.06 (3.49)	6.69 (2.27)	35.00 (10.83)	31.87 (11.72)	22.56 (8.16)	20.88 (9.89)

Note: Values are means with standard deviations in parentheses. n = 16 per condition.

Physical exercise and learning

To address RQ1, a 2 × 2 mixed-design ANOVA with Condition (walking vs. sitting) as the between-subjects factor and Time (immediate vs. delayed posttest) as the within-subjects factor revealed a significant main effect of Time, $F(1, 30) = 42.33$, $p < .001$, $\eta_p^2 = .585$, indicating that MWE scores declined from immediate to delayed posttest across both conditions, as expected (See Table 1). A significant main effect of Condition was also found, $F(1, 30) = 8.45$, $p = .007$, $\eta_p^2 = .220$, suggesting overall performance differences between the walking and sitting groups. However, the Time × Condition interaction was not significant, $F(1, 30) = .04$, $p = .854$, $\eta_p^2 = .001$, indicating that both groups forgot at a similar rate over the one-week period (see Table 2). These results suggest that a short bout of treadmill walking prior to a learning session enhanced MWE acquisition, as evidenced by significantly higher scores in the walking condition at both immediate and delayed posttests. However, the non-significant interaction indicates that exercise did not differentially affect retention over the one-week period. Levene's test indicated unequal variance at the delayed posttest ($p = .004$); however, group sizes were equal, and the analysis was considered robust to this violation.

Table 2. **Summary of 2 × 2 mixed-design ANOVA results for all outcome measures**

Measure / Source	df	MS	F	p	n_p^2
MWE Posttest					
Time	1, 30	172.27	42.33	<.001	.585
Condition	1, 30	206.64	8.45	.007	.220
Time × Condition	1, 30	0.14	0.04	.854	.001
Positive Affect					
Time	1, 30	97.52	5.88	.022	.164
Condition	1, 30	1,732.64	8.28	.007	.216
Time × Condition	1, 30	500.64	30.20	<.001	.502
Negative Affect					
Time	1, 30	147.02	4.78	.037	.137
Condition	1, 30	97.52	0.88	.357	.028
Time × Condition	1, 30	28.89	0.94	.340	.030

Note: n_p^2 – partial eta squared.

Physical exercise and positive affect

To address RQ2, a 2 × 2 mixed-design ANOVA with Condition (walking vs. sitting) as the between-subjects factor and Time (pre vs. post) as the within-subjects factor revealed a significant main effect of Time, $F(1, 30) = 5.88$, $p = .022$, $\eta_p^2 = .164$, and a significant main effect of Condition, $F(1, 30) = 8.28$, $p = .007$, $\eta_p^2 = .216$. Critically, a significant Time × Condition interaction was also found, $F(1, 30) = 30.20$, $p < .001$, $\eta_p^2 = .502$. Follow-up pairwise comparisons with Bonferroni correction revealed no significant difference between conditions at pretest ($MD = 4.81$, $SE = 3.70$, $p = .203$), but a significant difference at post-test ($MD = 16.00$, $SE = 3.81$, $p < .001$). The walking group showed an increase in positive affect from pre- to post-intervention ($M = 39.81$, $SD = 10.09$ to $M = 47.88$, $SD = 9.77$), whereas the sitting group showed a slight decrease ($M = 35.00$, $SD = 10.83$ to $M = 31.87$, $SD = 11.72$). This indicates that walking significantly improved the participants' positive affect.

For negative affect, a significant main effect of Time was found, $F(1, 30) = 4.78$, $p = .037$, $\eta_p^2 = .137$, indicating that negative affect decreased from pre- to post-intervention across both conditions. However, neither the main effect of Condition, $F(1, 30) = .88$, $p = .357$, $\eta_p^2 = .028$, nor the Time × Condition interaction, $F(1, 30) = .94$, $p = .340$, $\eta_p^2 = .030$, reached significance, suggesting that the reduction in negative affect did not differ between the walking (M = 21.44, SD = 8.30 to M = 17.06, SD = 7.11) and sitting (M = 22.56, SD = 8.16 to M = 20.88, SD = 9.89) conditions (see Table 2). This reduction in negative affect across both conditions could be due to elevated negative affect at the start of the experiment due to demand ambiguity and uncertainty at the onset resulting in higher levels of anxiety that diminished as the experiment progressed.

Fitness level as covariate

To address RQ3, before conducting the ANCOVAs, the homogeneity of regression slopes assumption was tested by examining the interaction between fitness level and condition, which was non-significant, confirming the assumption was met. ANCOVAs were conducted for both the immediate and delayed posttests with Condition as the fixed factor and fitness level as the covariate. Fitness level was not significant for either the immediate posttest, $F(1, 29) = 0.73$, $p = .401$, $\eta_p^2 = .024$, or the delayed posttest, $F(1, 29) = 0.11$, $p = .748$, $\eta_p^2 = .004$. Importantly, the main effect of Condition remained significant for both the immediate posttest, $F(1, 29) = 6.39$, $p = .017$, $\eta_p^2 = .181$, and the delayed posttest, $F(1, 29) = 7.83$, $p = .009$, $\eta_p^2 = .213$, indicating that the walking group's enhanced performance on the MWE tests at both time points could not be attributed to pre-existing differences in fitness level between groups.

4. DISCUSSION

This study examined the effects of physical activity (PA) on vocabulary acquisition and affect in an EFL context. Results indicated that walking on a treadmill prior to a learning session improved MWE acquisition in both immediate and delayed posttests compared to sitting/reading condition. However, PA did not reduce memory decay over time relative to the sitting/reading condition. Positive affect improved significantly following the walking condition, whereas participants in the sitting/reading condition reported lower positive affect compared to their baseline ratings. Negative affect decreased significantly from pre- and post-PANAS tests. However, there were no differences between conditions, and the pattern of change over time did not differ by condition. These results suggest that PA not only improves physical health and wellbeing but may also support short-term learning and mood enhancement in controlled settings. The findings of this exploratory study should be interpreted with caution given the small sample size. However, the observed effect sizes suggest that the relationship between PA, memory, and positive affect in L2 learning warrants further investigation.

In addition, results from this study support and extend a number of recent studies highlighting the distinct contribution of PA to various cognitive processes, including attention (Fernandes M. de Sousa et al., 2019), memory (Birdsell, 2023; Schmidt-Kassow et al., 2014), and creativity (Bollimbala & James, 2024). Most closely relevant is how this study extended earlier research (Birdsell, 2023), which used a within-subject design with EFL learners and found a small but statistically significant improvement of delayed posttest scores following treadmill walking. The present study replicates this finding and strengthens it by using a more rigorous randomised controlled trial design. Additionally, whereas Birdsell (2023) could not fully control for prior vocabulary knowledge, the use of MWEs addressed this limitation be selecting items unfamiliar to all participants, providing a cleaner test of the memory effects. The present findings also align with Schmidt-Kassow et al. (2014), who demonstrated that treadmill walking during vocabulary encoding benefited long-term recall, though that study used a concurrent rather than pre-learning exercise design, suggesting that the cognitive benefits of PA on vocabulary memory appear across different exercise timing arrangements. A notable new contribution of the present study is the inclusion of fitness level as a covariate, which did not account for the observed group differences, indicating that the memory benefits observed in this study are not the result of baseline fitness differences between the groups. Finally, by specifically examining L2 learners of English, this study addresses a gap in the literature that has primarily focused on L1 populations, and contributes to preliminary evidence that the cognitive benefits of acute PA extend to foreign language vocabulary learning.

Exercise changes the structure of the brain, as early studies are beginning to show how exercise training in schools has the potential to affect cortical and subcortical brain regions associated with cognition and mental health (Valkenborghs et al., 2026). Such studies indicate that exercise is not just about staying fit but also plays a role in learning and wellbeing. Moreover, exercise has been widely linked to improving core executive functions, which are important for planning, problem-solving, and learning (Leahy et al., 2020). The study presented in this article contributes to the literature by specifically addressing memory retention and positive affect among L2 learners of English. There are a number of pedagogical implications that this study has for the field of education.

Pedagogical implications

University classrooms are exceedingly sedentary (Bailey et al., 2026) with a primary focus on the exchange of information through lecture or group discussions. To tackle this 'sedentary' problem in education, many educators are currently promoting an embodied learning approach that encourages students and teachers to use more movement in the classroom, including the use of gesture and enactment (Macrine & Fugate, 2022). Gesture and enactment have shown to improve learning outcomes, as they ground the abstract concept being learned in the physical, thus coupling the meaning to the sensorimotor systems (Birdsell, 2021; Macedonia, 2014).

The use of gestures has the potential to enhance vocabulary learning by storing the vocabulary items in both visual and motor cortical areas, resulting in deeper semantic representation (Mayer et al., 2015). Other researchers have also shown that the benefit of gestures to enhance vocabulary retention is particularly strong when the individual learners perform the gestures themselves (Macedonia & Klimesch, 2014; Morett, 2014). In a similar line of research often referred to as the 'enactment effect' (Engelkamp & Jahn, 2003), researchers have shown that performing an action can facilitate the learning and recall of verbal information (Birdsell, 2021). Furthermore, in a systematic review and meta-analysis study, researchers examined evidence from behavioural, neuroimaging, and patient work on the 'enactment effect' and found that physically performing the movement lead to significantly better memory than simply reading or hearing about it (Roberts et al., 2022). They concluded that the memory boost comes from both planning the action and the physical contribution of the action itself. Evidence from the present study expanded this idea by examining how the physical action of movement itself contributes to improved memory retention.

From a practical perspective, research into embodied learning highlights the important role movement plays in vocabulary acquisition, yet significant hurdles remain for teachers, particularly at the tertiary level. First, there is the widespread belief held by teachers, students, and university administrators alike that learning is best done through sedentary behaviour, and incorporating movement such as a walking activity would be viewed as disruptive and unproductive use of time. Second, there are physical constraints in most classrooms, which are typically designed to minimise movement, with fixed, desk-bound seating covering most of the floor space. As the evidence for embodied learning accumulates and disseminates through society, schools will hopefully begin to reflect this shift in classroom design, with more open and modular spaces, and in greater acceptance of movement as a tool for learning. Class time could benefit from what Keinänen (2016) called *walking-for thinking*, which is described as a "moving gestalt, an interplay between the person, environment and thinking where the rhythms of the body correlate with the rhythm of walking, affording feeling of enhanced memory and creativity" (p. 593).

Furthermore, this study illustrates how a short bout of PA has the potential to boost positive affect. Being in a positive mood has several cognitive and pedagogical advantages. For example, positive affect shifts information processing to a more broad and diffuse attentional focus, resulting in the broadening of thought–action routines, promoting exploratory behaviour (Fredrickson & Branigan, 2005). This diffuse attentional focus potentially enhances learning and creativity.

The present study offers a practical starting point for educators interested in incorporating movement into their teaching. Building upon theories of embodied learning, which focus on the use of gestures, enactment, and other hands-on activities, PA such as walking has the potential to improve learning outcomes. For EFL instructors in particular, the findings suggest that even a brief, 20-minute walk prior to a vocabulary learning session may prime students cognitively and affectively for the task, improving both retention and mood. While the controlled nature of this study limits direct application to real classrooms, it suggests the need to explore how including short movement breaks into the lesson, particularly before vocabulary learning, could be an effective pedagogical method for learning and not an ineffective use of time.

Limitations

Several limitations of this study should be noted. First, the small sample size (N = 32) reduces statistical power and makes it difficult to generalise the findings. Second, the study drew exclusively from Japanese university EFL learners at a single institution, which limits the extent to which the results can be applied to other educational contexts. Third, no physiological data (e.g. heart rate) were collected during the walking condition, meaning exercise intensity was not objectively verified. Finally, although students showed similar near-zero pretest scores, overall L2 proficiency likely varied among participants. Further studies should incorporate a standardised proficiency measure to examine whether L2 ability functions as a covariate.

5. CONCLUSIONS

In conclusion, the present study contributes to the growing body of research on how the body impacts various cognitive processes. Results in this study indicate that walking should be included more widely in educational settings, not only for reducing the amount of sedentary time students experience throughout the day, but also to improve their mood and enhance their learning. To better understand how movement affects learning, future research should use ecologically valid designs in which students walk during class time before a learning task and then assess whether the effects observed in controlled settings replicate in real-world learning contexts.

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Informed Consent Statement: The experiment was approved by the Ethics Review Board at Hirosaki University in Japan. All participants were informed about the aims of the study, gave their written consent, and could withdraw from the study without any penalty.

Declaration of Generative Artificial Intelligence (GenAI) Use: Anthropic's Claude (Sonnet 4.5) was used for brainstorming research design and proofreading. The author checked and revised the content of the article and takes full responsibility for the text within.

Conflicts of Interest: The author declares no conflict of interest associated with this manuscript.

REFERENCES

Anthropic. (2026). *Claude 4.5 Sonnet* [Large language model]. https://claude.ai/new

Bailey, R. P., Hoe, T. W., Morrison, G. Z., Ali, A., & Samsudin, N. (2026). Rethinking higher education: Embodied learning and pedagogical transformation. *Higher Education*, 1–21. Advance online publication. https://doi.org/10.1007/s10734-025-01581-2

Birdsell, B. J. (2021). Enhancing phrasal verb learning: A quasi-experimental study of different approaches. In P. Clements, R. Derrah, & P. Ferguson (Eds.), *Communities of teachers & learners*. JALT. https://doi.org/10.37546/JALTPCP2020-30

Birdsell, B. J. (2023). Exercising before learning enhances long-term memory for foreign language vocabulary and improves mood. *Journal for the Psychology of Language Learning*, *5*(1), e5112123. https://doi.org/10.52598/jpll/5/1/3

Bollimbala, A., & James, P. S. (2024). Impact of chronic physical activity on individuals' creativity. *Psychological Research*, *88*(2), 684–694. https://doi.org/10.1007/s00426-023-01862-4

Bourke, M., Phillips, S. M., Gilchrist, J., & Pila, E. (2024). The pleasure of moving: A compositional data analysis of the association between replacing sedentary time with physical activity on affective valence in daily life. *Psychology of Sport and Exercise*, *75*, 102724. https://doi.org/10.1016/j.psychsport.2024.102724

Chang, Y.-K., Ren, F.-F., Li, R.-H., Ai, J.-Y., Kao, S.-C., & Etnier, J. L. (2025). Effects of acute exercise on cognitive function: A meta-review of 30 systematic reviews with meta-analyses. *Psychological Bulletin*, *151*(2), 240–259. https://doi.org/10.1037/bul0000460

Engelkamp, J., & Jahn, P. (2003). Lexical, conceptual and motor information in memory for action phrases: A multi-system account. *Acta Psychologica*, *113*(2), 147–165. https://doi.org/10.1016/S0001-6918(03)00030-1

Fernandes M. de Sousa, A., Medeiros, A. R., Del Rosso, S., Stults-Kolehmainen, M., & Boullosa, D. A. (2019). The influence of exercise and physical fitness status on attention: A systematic review. *International Review of Sport and Exercise Psychology*, *12*(1), 202–234. https://doi.org/10.1080/1750984X.2018.1455889

Fredrickson, B. L., & Branigan, C. (2005). Positive emotions broaden the scope of attention and thought-action repertoires. *Cognition & Emotion*, *19*(3), 313–332. https://doi.org/10.1080/02699930441000238

Herbert, C. (2022). Enhancing mental health, well-being and active lifestyles of university students by means of physical activity and exercise research programs. *Frontiers in Public Health*, *10*, 849093. https://doi.org/10.3389/fpubh.2022.849093

Hötting, K., Schickert, N., Kaiser, J., Röder, B., & Schmidt-Kassow, M. (2016). The effects of acute physical exercise on memory, peripheral BDNF, and cortisol in young adults. *Neural Plasticity*, *2016*(1), 6860573. https://doi.org/10.1155/2016/6860573

Kawahito, J., Otsuka, Y., Kaida, K., & Nakata, A. (2011). Reliability and validity of the Japanese version of 20-item Positive and Negative Affect Schedule. *Hiroshima University Psychology Research Journal*, *11*(1), 225–240. https://doi.org/10.15027/32396

Keinänen, M. (2016). Taking your mind for a walk: A qualitative investigation of walking and thinking among nine Norwegian academics. *Higher Education*, *71*(4), 593–605. https://doi.org/10.1007/s10734-015-9926-2

Kvam, S., Kleppe, C. L., Nordhus, I. H., & Hovland, A. (2016). Exercise as a treatment for depression: A meta-analysis. *Journal of Affective Disorders*, *202*, 67–86. https://doi.org/10.1016/j.jad.2016.03.063

Lambourne, K., & Tomporowski, P. (2010). The effect of exercise-induced arousal on cognitive task performance: A meta-regression analysis. *Brain Research*, *1341*, 12–24. https://doi.org/10.1016/j.brainres.2010.03.091

Leahy, A. A., Mavilidi, M. F., Smith, J. J., Hillman, C. H., Eather, N., Barker, D., & Lubans, D. R. (2020). Review of high-intensity interval training for cognitive and mental health in youth. *Medicine & Science in Sports & Exercise*, *52*(10), 2224–2234. https://doi.org/10.1249/MSS.0000000000002359

Liu, L., Shi, Y., Li, T., Qin, Q., Yin, J., Pang, S., Nie, S., & Wei, S. (2016). Leisure time physical activity and cancer risk: Evaluation of the WHO's recommendation based on 126 high-quality epidemiological studies. *British Journal of Sports Medicine*, *50*(6), 372–378. https://doi.org/10.1136/bjsports-2015-094728

Löllgen, H., Böckenhoff, A., & Knapp, G. (2009). Physical activity and all-cause mortality: An updated meta-analysis with different intensity categories. *International Journal of Sports Medicine*, *30*(03), 213–224. https://doi.org/10.1055/s-0028-1128150

Ludyga, S., Gerber, M., Brand, S., Holsboer-Trachsler, E., & Pühse, U. (2016). Acute effects of moderate aerobic exercise on specific aspects of executive function in different age and fitness groups: A meta-analysis. *Psychophysiology*, *53*(11), 1611–1626. https://doi.org/10.1111/psyp.12736

MacCallum, R. C., Widaman, K. F., Zhang, S., & Hong, S. (1999). Sample size in factor analysis. *Psychological Methods*, *4*(1), 84–99. https://doi.org/10.1037/1082-989X.4.1.84

Macedonia, M. (2014). Bringing back the body into the mind: Gestures enhance word learning in foreign language. *Frontiers in Psychology*, *5*, 1467. https://doi.org/10.3389/fpsyg.2014.01467

Macedonia, M., & Klimesch, W. (2014). Long-term effects of gestures on memory for foreign language words trained in the classroom. *Mind Brain and Education*, *8*(2), 74–88. https://doi.org/10.1111/mbe.12047

Macrine, S. L., & Fugate, J. M. (Eds.). (2022). *Movement matters: How embodied cognition informs teaching and learning*. MIT Press

Mayer, K. M., Yildiz, I. B., Macedonia, M., & von Kriegstein, K. (2015). Visual and motor cortices differentially support the translation of foreign language words. *Current Biology*, *25*(4), 530–535. https://doi.org/10.1016/j.cub.2014.11.068

Moon, R. (2015). Multi-word items. In J. R. Taylor. (Ed.), *The Oxford handbook of the word* (1st ed., pp. 120–140). Oxford University Press.

Morett, L. M. (2014). When hands speak louder than words: The role of gesture in the communication, encoding, and recall of words in a novel second language. *Modern Language Journal*, *98*(3), 834–853. https://doi.org/10.1111/modl.12125

Myers, J. (2003). Exercise and cardiovascular health. *Circulation*, *107*(1), e2–e5. https://doi.org/10.1161/01.CIR.0000048890.59383.8D

Roberts, B. R., MacLeod, C. M., & Fernandes, M. A. (2022). The enactment effect: A systematic review and meta-analysis of behavioral, neuroimaging, and patient studies. *Psychological Bulletin*, *148*(5–6), 397. https://doi.org/10.1037/bul0000360

Roig, M., Nordbrandt, S., Geertsen, S. S., & Nielsen, J. B. (2013). The effects of cardiovascular exercise on human memory: A review with meta-analysis. *Neuroscience & Biobehavioral Reviews*, *37*(8), 1645–1666. https://doi.org/10.1016/j.neubiorev.2013.06.012

Schmidt-Kassow, M., Zink, N., Mock, J., Thiel, C., Vogt, L., Abel, C., & Kaiser, J. (2014). Treadmill walking during vocabulary encoding improves verbal long-term memory. *Behavioral and Brain Functions*, *10*(1), 24. https://doi.org/10.1186/1744-9081-10-24

Valkenborghs, S. R., Hillman, C. H., Smith, J. J., Leahy, A. A., Steedman, S. W., Ramadan, S., & Lubans, D. R. (2026). Effects of high-intensity interval training on subcortical and cortical brain volumes in older adolescents: Findings from the "Burn 2 Learn" cluster randomized controlled trial. *Psychophysiology*, *63*(1), e70215. https://doi.org/10.1111/psyp.70215

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063. https://doi.org/10.1037/0022-3514.54.6.1063

Winter, B., Breitenstein, C., Mooren, F. C., Voelker, K., Fobker, M., Lechtermann, A., Krueger, K., Fromme, A., Korsukewitz, C., Floel, A., & Knecht, S. (2007). High impact running improves learning. *Neurobiology of Learning and Memory*, *87*(4), 597–609. https://doi.org/10.1016/j.nlm.2006.11.003

World Health Organization. (2010). *Global recommendations on physical activity for health* (p. 53). WHO Press. https://www.who.int/publications/i/item/9789241599979

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