







Comprehension of Physical Activity Promotion Material: A Retrospective and Comparative Analysis

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Abstract

The readability of health promotion material is often judged using reading grade level (RGL) formulas. However, formulas do not reliably factor in prior knowledge and context clues, which affect readability. Only one known study has directly measured physical activity promotion material comprehension (i.e., Cardinal & Seidler, 1995, using the cloze procedure). The purpose of the present study was to analyze the generalizability of the prior study's findings using a two-step study design. Study 1 compared subgroup comprehension scores from the prior study to cloze procedure interpretive cut-points since that step was not taken previously. Study 2 tested mock material comprehension using the cloze procedure, then analyzed comprehension scores from each study compared to the interpretive cut-points. Study 1 participants were adults purposively sampled, then categorized by educational attainment (i.e., college/no college degree, $N = 56$, test material RGL = 18.52, per SMOG-formula). Study 2 participants were adult college students conveniently sampled ($N = 25$), then randomized by test material SMOG RGL: 11th (typical level) versus 8th (max level recommended for lay adult audience). The conclusions from the previous study were partially confirmed: only one subgroup had inadequate comprehension (no college degree group). The 11th RGL material had inadequate comprehension, too. The 8th RGL material needed revision (better context clues) before performing as expected (i.e., greatest comprehension level, met cut-point for adequate comprehension). The findings of this study signify the need to pilot test physical activity promotion material to ensure writing at recommended RGL levels would likely promote adequate comprehension.

Keywords: Exercise science, health communication, health equity, health literacy, replication science

1 Introduction

Educational practices in physical activity promotion can promote health literacy specific to exercise (e.g., for self-care and self-management against chronic diseases; Hosseinzadeh et al., 2022). Readability research, however, suggests most materials in print and online circulation are not ready to be disseminated because they are hard to understand (Thomas et al., 2022b). Designing health promotion materials to meet recommended reading grade levels (i.e., at/below an 8th-grade

level) would help ensure materials are understood by adults with low and high health literacy (Kim & Lee, 2016; Sheridan et al., 2011). Personalized understanding of physical activity guidelines and achieving adequate/proficient health literacy are positively correlated with meeting one or more recommendations for physical activity per week (Abula et al., 2018; Buja et al., 2020; Kickbusch et al., 2013; Lim et al., 2021).

Cardinal and Seidler (1995) were the first to directly study the degree to which lay adults may understand physical activity promotion material. Their innovative results suggested that writing

above the 8th reading grade level (the max-cut point recommended)¹ would likely cause inadequate comprehension in lay adults, regardless of educational attainment. According to the interpretive cut-points of their employed method (i.e., cloze procedure)², mean subgroup scores did not meet the cut-point for fully comprehending the test material without supplemental instruction. An implication of their study is that promotion material developed to foster understanding of physical activity guidelines is not suitable for end-users with a wide-range of educational attainment (i.e., high school, some college, college and graduate degree; Cardinal & Seidler, 1995).

Given the implications of the Cardinal and Seidler (1995) study results for public health (Smith et al., 2022a,b), it is surprising that the present study, currently, is the only known study that has sought to replicate their results. Thomas et al. (2021) did a systematic search of readability research in kinesiology and found only one study that measured comprehension directly, the one by Cardinal and Seidler (1995). Thomas et al. performed their search in 2020, and we replicated their search process one year later while including method-specific search terms (e.g., "comprehension", "cloze procedure"). Despite this more detailed search, we drew the same conclusion (Vega et al., 2021). Before this present investigation, there was only one known published study that has directly investigated the comprehension of physical activity promotion material. That study was Cardinal & Seidler (1995).

While illuminating the need to pilot test physical activity promotion material for readability and other suitability issues (e.g., Cardinal, 1995; Vallance et al., 2008), the study by Cardinal and Seidler (1995) had its limitations which should have been addressed by future research testing the replicability of their results (Halperin et al., 2018). Beyond using a single condition design, their test material was written at a graduate school reading grade level (e.g., 18.52 per the SMOG formula; McLaughlin, 1969); this estimate may have been seven to eight grade levels higher than the typical reading grade level of physical activity promo-

tion material. For example, Cardinal (1993) analyzed a representative sample and showed the typical reading grade level for physical activity promotion material may be at the high school level (i.e., $M = 11.28$, $SD = 1.83$, $99\% CI = [10.70, 11.86]$, $N = 75$). Per the confidence intervals reported in that study, the mean reading grade level would not statistically differ from the meta-mean reported by Thomas and colleagues (2018) in their meta-analysis (i.e., $M = 10.25$, $95\% CI = [9.62, 10.91]$, $N = 819$, $K = 14$), which also suggested a high school reading grade level is typical for physical activity promotion material. Moreover, Cardinal and Seidler (1995) grouped their participants by level of educational attainment, but they did not test their subgroup scores against their procedure's interpretive cut-points for (a) *not capable of comprehension*, (b) *somewhat capable of comprehension*, and (c) *fully capable of comprehension without supplemental instruction* (Cardinal & Seidler, 1995). Descriptively, all subgroups fell within the middle category per their mean values, but the college degree group appeared close to the latter cut-point.

Given the implications and limitations of the only known study to directly investigate physical activity promotion material comprehension in lay adults, the purpose of the present study was to retrospectively test the Cardinal and Seidler subgroup data against the interpretive cut-points of their procedure. This retrospective analysis aims to clarify the generalizability of their findings. Another purpose was to compare the Cardinal and Seidler subgroup results to our pilot test results done as part of an ongoing study to systematically replicate their methods (i.e., using the cloze procedure) to directly test the comprehension of mock physical activity promotion material written at two reading grade levels: i.e., (a) the 11th reading grade level (a typical level for physical activity promotion material) and (b) the 8th reading grade level (what is recommended). This comparative analysis will further clarify the generalizability of their findings.

2 Methods

2.1 Theoretical Framework

Cardinal and Seidler (1995) used the cloze procedure to directly test comprehension of one physical activity promotion material (a brochure).³ The

¹Health communication research suggest most adults read comfortably at the 8th reading grade level (Mayer & Villaire, 2009), and numerous government agencies and professional associations have endorsed that cut-point as the max level for lay communication (Han & Carayannopoulos, 2020).

²The cloze procedure derives from Gestalt psychology. It requires participants to guess the exact word(s) missing from a passage of text, which were removed systematically (Taylor, 1953, 1957). For a visual example, see Nielsen, (2011).

³The brochure analyzed by Cardinal and Seidler was presumed to be light reading for the general public. It was co-

cloze procedure is based on Gestalt psychology. It requires participants to complete sentences from a passage of text after the words are removed. The procedure assumes writing is a relationship where effective writing is predictable. It presumes that the easier readers can use prior knowledge and context clues to correctly guess exact words missing from a passage of text, the easier the text is to read, understand, and retain. The cloze procedure was developed to study text written in English, which has redundancy within how sentences are formed (e.g., articles, prepositions; Taylor 1953). Second, for a given passage of text, some words make more sense to use than others to complete a sentence due to the implied context of the passage of text and habitual ways things are phrased within a broader culture (Taylor, 1953). For example, try completing the following example sentence (for each blank, only use one exact word):

If you lift with [blank] back instead of your [blank], you are more likely [blank] get hurt.

See the footnote⁴ for the answer. After some thought, we suspect most people reading this article would have correctly guessed the missing words.

Taylor (1953) argued that formulas used to estimate the reading grade level of a passage of text do not reliably capture factors that impede comprehension (e.g., little to no prior knowledge or awkward sentences). His preliminary study showed the number of correct guesses was a better predictor of reading difficulty (i.e., literacy demand) than formulas used to estimate reading grade level alone (because reading grade level formulas rely mainly on counting syllables and sentences; Taylor 1953). Doak et al. (1985, cited in Cardinal & Seidler, 1995) proposed interpretive cut-points for evaluating the degree adults comprehended health-related materials based on the results of the cloze procedure: i.e., correctly guessing $\geq 60\%$ of the missing words means, likely capable of fully comprehending text without supplemental instruction (i.e., independently); correctly guessing 40 to 59.99% of the missing words means, likely needs supplemental instruction to fully comprehend text; and correctly guessing $< 40\%$ of the missing words means likely not capable of comprehending text as writ-

ten—revise the text and use verbal and visual communication. These same interpretive cut-points were presented within the second edition of their textbook, the latest known edition of the textbook (i.e., Doak et al., 1996b).

It appears that Doak et al. (1985/1996b) based their suggested interpretive cut-points on experimental research showing two key outcomes: (a) a cloze percentage score of 57-61% on average correlated with a multiple-choice comprehension score of 90%, the established cut-point indicating ability to fully understand text without instruction (i.e., independently), and a score of 41-44% on average correlated with a multiple-choice comprehension score of 75%, the established cut-point indicating a need for instruction before text could be fully understood (Rankin & Culhane, 1969). Similar findings were observed for oral reading tests (Bormuth, 1968a). Doak et al. (1996b) provided little detail explaining why their cut-points differed slightly from the published studies. They suggest their cut-points provide a conservative estimate for interpreting cloze scores across diverse populations (Doak et al., 1996b; for example see Aitken, 1977, p. 63; Bormuth, 1968b, pp. 193-194; Rankin & Culhane, 1969, pp. 197-198). Cardinal and Seidler (1995) used the suggested interpretive cut-points by Doak et al. (1985) to determine the degree their adult sample could comprehend the test brochure. The aforementioned cut-points were republished within the second edition of the Doak et al. textbook (Doak et al., 1996b). For the present investigation, we used the same cloze procedure protocol and interpretive cut-points as Cardinal and Seidler (1995).

2.2 Study Design

Two studies were performed and reported in this article to address the aims of the present investigation. In summary, a retrospective analysis (Study 1) was performed on the Cardinal and Seidler (1995) summary data (i.e., a reanalysis). Study 1 investigated if the mean scores of each subgroup significantly differed from cloze procedure interpretive cut-points (e.g., the 40% correct answer cut-point, the 60% correct answer cut-point). Study 2 tested the cloze comprehension for test material written at two reading grade levels not investigated in the Cardinal and Seidler (1995) study (i.e., 11th and 8th grade). The results from Study 1 and 2 were then compared (e.g., mean scores and cut-point comparisons).

published by the US Centers for Disease Control and Prevention and the American College of Sports Medicine (Cardinal & Seidler, 1995).

⁴Answer key: If you lift with your back instead of your legs, you are more likely to get hurt.

2.2.1 Study One

The first study was a retrospective analysis. The summary statistics Cardinal and Seidler (1995) reported for their sample subgroups were extracted from their article for statistical comparison against the interpretive cut-points of the cloze procedure (i.e., tested if means differed from the cut-point values). While health literacy level is a more robust predictor of comprehension than educational attainment, educational attainment is still positively associated with comprehension (Weiss et al., 2005). For example, Weiss et al. (2005) showed that educational attainment strongly predicted which adults had adequate and low health literacy skills 72% of the time (Weiss et al., 2005), according to the ROC curve test statistic (Weiss et al., 2005; Carter et al., 2016). The Cardinal and Seidler (1995) study results, however, suggest regardless of educational attainment, most individuals in their sample would have likely needed supplemental instruction to fully understand their test brochure written at a graduate school reading level (i.e., Sample M cloze score = 54%, SD = 13.4%). This implication should be verified using retrospective analysis since the mean scores for their college degree-level-subgroups appeared equivalent with the cut-point (60%), indicating an ability to fully understand the material without instruction (i.e., Bachelor's degree versus Master's degree, M was 59.2%, SD = 12.2% and M was 57.4%, SD = 8.2%, respectively).⁵

2.2.2 Study Two

Study two was to test the efficacy of a research protocol developed to systematically replicate the Cardinal and Seidler (1995) study. Specifically, study two was to verify if their protocol could be adapted to test the comprehension of mock online physical activity promotion material (i.e., web articles) written at two reading grade levels (11th and 8th grade). Thomas and colleagues (2023a) developed the mock material, and they chose the two reading grade level targets because of their ecological validity: the first target (an 11th reading grade level) is the typical reading level of online written advice about physical activity (e.g., web articles or blogs; Thomas et al., 2022b), and the second target (an 8th reading grade level) is the target level that health-related resource material should not

⁵Cardinal and Seidler (1995) used the analysis of variance (ANOVA) test to test difference between subgroups, only, not against cut-points used to interpret cloze procedure results.

exceed according to experts in health communication (Han & Carayannopoulos, 2020). Twenty-five individuals, eighteen years or older, enrolled as undergraduate students at the first author's university, participated in study two.

Study two had three phases: (a) phase one, was a pilot test of the survey website designed to administer the online cloze procedure (participants were volunteers from the first author's lab, $n = 12$)⁶; prior to pilot testing in phase one, a valid and reliable rating form was used to ensure the website had good usability (e.g., it had easy navigation and was screen-reader friendly; Wu et al., 2022, 2023) (b) phase two occurred because the 8th reading grade level material did not have better comprehension than the 11th reading grade level material, thus the 8th reading grade level material was revised per the theoretical underpinnings of the cloze procedure (Taylor, 1953), then comprehension for the revised material was checked in phase two (participants were undergraduate research assistants uninvolved with the material's creation or adaptation, $n = 3$) and (c) phase three, was to check if the results previously observed, for the 11th reading grade level material and the revised 8th reading grade level material, would replicate with a new sample of participants (i.e., a randomly stratified subsample recruited for the larger replication study, $n = 10$). For more detail, refer to Figure 1.

The research protocol for study two was approved by the university institutional review board of the first author (primary investigator). Given the aims of study two was not to generalize to specific populations (but rather to investigate the functionality and validity of the research protocol and instruments), demographic data was not recorded for study two participants beyond what was already reported (i.e., college attending adults, 18 years or older, completing an undergraduate degree program).

2.3 Analytic Plan

The analytic plan had several components. First, intra and inter-rater reliability was checked using the cloze forms completed in study two, phase 3. Two measures of rater reliability were used: (a) the intraclass correlation coefficient (ICC) for ab-

⁶The survey website was developed using the Canvas web application software. The mock material was converted into an online cloze form using the quiz-option for fill-in-the-blank prompts (i.e., the entire mock article was a single quiz "question/prompt", with each blank space an answer option; Instructure, n.d.).

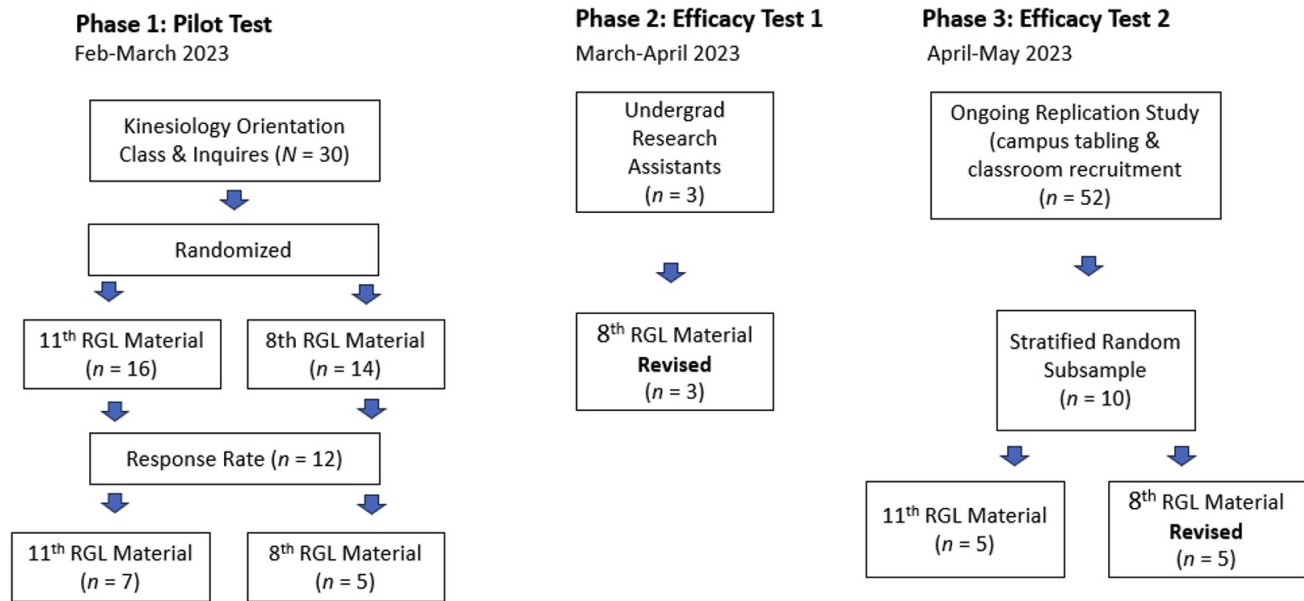


Figure 1: Three panel figure, showing the sampling procedure to each phase of study two within the present investigation. The “revised” label denotes that the test material was revised and then retested, given the pilot-test results suggested low construct validity (i.e., cloze comprehension scores for the original 8th reading grade level material were less than the scores for 11th reading grade level material). Two efficacy tests were performed to test if edits improved the 8th-grade reading material’s construct validity (i.e., Phase 2: Efficacy Test 1), then confirm if those findings would replicate (i.e., Phase 3: Efficacy Test 2). According to both efficacy tests, the revised 8th-grade material had improved construct validity (i.e., greater comprehension scores).

solute rater agreement and using a two-way random effects model (Landers, 2015) and (b) Krippendorff’s alpha coefficient for ordinal measures (Freelon, 2013; Thomas et al., 2022b). Intra-rater reliability was assessed using a 3-day grace period for the first author, the primary coder for the study. Inter-rater reliability was assessed using the ratings of the first and second authors. Rater reliability scores were evaluated using the established interpretive cut-points for the ICC measure (Cicchetti, 1994) and Krippendorff’s alpha coefficient (Landis & Koch, 1977). Second, one-sample *t*-tests were used to test if subgroup means differed from cloze score interpretive cut-points. A web tool for conducting one-sample *t*-tests using summary statistics was used (@ZACH, 2020). Third, independent samples *t*-tests were used to compare within and between-study subgroups. Summary statistics were used, and this computation was done in SPSS (*Statistical Package for the Social Sciences*).

Statistical significance was set at $p \leq .10$, given the exploratory nature of the present investigation (Vaske, 2019). Bonferroni adjustments were

made in the event of multiple comparisons (but this correction was used sparingly, given the formula is a bit too conservative; see Morgan et al., 2006, pp. 155, 184). Using a free web tool, we computed effect size estimations to determine the magnitude of observed differences (i.e., Hedge’s *g* for between-group differences and Glass’ delta (Δ) for cut-point comparisons; SocialScienceStatistics.com, n.d.). Established interpretive cut-points were used to evaluate the effect size results (Vaske et al., 2002).

3 Results

3.1 Reliability Results

Scoring for the cloze submissions had excellent intra- and inter-rater reliability. For more detail, refer to Table 1. Inter-rater reliability revealed one discrepancy with the 11th reading grade level (RGL) material. The wrong word was deleted for space 42 within the online cloze form. The cause of this error is unknown, given the answer key was

correct. Moreover, the first author noticed similar errors when pasting the cloze form from the Microsoft Word document into the Canvas text editor (e.g., spaces would be deleted). While the forms were checked systematically by the research team before their utilization, the aforementioned error did slip through. The answer key was adjusted to correctly code the space for item 42 within the online form, before performing descriptive and analytic analyses. Additionally, the first author conducted a line-by-line check using print copies of the answer key and online cloze form. No other errors were observed.

Table 1: Rater Reliability Test Results in Scoring Cloze Submissions

Material	Intra-Rater Reliability	
	ICC ¹	K. alpha
8th RGL ² Cloze	.99	.98
11th RGL ² Cloze	.83	.97
Material	Inter-Rater Reliability	
	ICC ¹	K. alpha
8th RGL ² Cloze	.99	.98
11th RGL ² Cloze	.98	.97

Notes. (1). ICC stands for intra-class correlation. A two-way random effects model for absolute agreement was used. (2). RGL stands for reading grade level. K. alpha stands for Krippendorff's alpha.

Three-day grace period used for the test-retest period.

Random sample subset ($n = 10$, 5 per condition), sampled from ongoing replication study (i.e., Study 2, phase 3 sample of the present study).

ICC interpretive cut-points (Cicchetti, 1994): Poor < .40, Fair = .41—.59, Good = .60—.74, Excellent = .75—1.0.

K. alpha interpretive cut-points (Landis & Koch, 1977): Poor < .00, Slight = .00—.20, Fair = .21—.40, Moderate = .41—.60, Substantial = .61—.80, Almost Perfect = .81—1.0.

3.2 Study One Results

When compared to the 40% cut-point, t-test results substantiated descriptive results for the no college degree group.⁷ On average, scores were not different from the minimum cut-point, and differences were small/minimal in magnitude. As suspected, the mean score for the no college degree group

⁷We combined Cardinal and Seidler's (1995) educational attainment subgroups into two groups: (a) no college degree (high school diploma & some college course work; $t = 0.124$, $df = 17$, $p = .903$) and (b) college degree (bachelor's degree & master's degree; $t = 0.369$, $df = 35$, $p = .714$); equal variance assumed, Bonferroni-adjusted p -value = .05. A free webtool was used (StatsToDo.com, n.d.)

was significantly less than the 60% cut-point. Observed differences were large/substantial in magnitude. Finally, the college degree group, on average, was similar to the 60% cut-point. Observed differences were small/minimal in magnitude. For more detail, refer to Table 2 and Table 3.

Table 2: Combined Group Means for the Study Subgroups

	Cardinal & Seidler Study ¹	
	No College Degree ³	College Degree ⁴
<i>n</i>	19	37
<i>Mean</i> (%)	44.59	58.86
<i>SD</i> (%)	12.07	11.47
	Present Study ⁵	
	11th RGL ²	8th RGL ²
<i>n</i>	12	8
<i>Mean</i> (%)	50.81	65.94
<i>SD</i> (%)	6.84	2.83

Notes. (1) The Cardinal and Seidler test material had a graduate school RGL (i.e., 18.52 per the SMOG formula). (2) RGL stands for reading grade level. (3) Individuals with a high school diploma and who completed some college courses. (4) Individuals who earned a bachelor's and master's degree. (5) Participants were current undergraduate students (mostly majoring in kinesiology); they would fall under the "no college degree group," for comparative purposes.

3.3 Study Two Results

The 11th RGL material group scores were larger than the 40% cut-point on average. Observed differences were large/substantial.⁸ At the same time, this group was less than the 60% cut-point on average. The 8th RGL material group scores exceeded the 60% cut-point on average. Observed differences were large/substantial.⁹

On average, the 8th RGL material group had greater comprehension than any other group. Compared to both the no college degree group (Cardinal & Seidler 1995 study) and the 11th RGL material group (present study), the difference was large/substantial. Compared to the college degree group (Cardinal & Seidler 1995 study), the difference was moderate/typical.

⁸The independent samples from phase 1-3 were combined as follows: 11th RGL material (phase 1 & 3; $t = 0.370$, $df = 7.343$, $p = .722$) and 8th RGL revised material (phase 2 & 3; $t = 1.465$, $df = 2.335$, $p = .263$); equal variance not assumed.

⁹According to study two descriptive statistics, it was only necessary to compare the 8th RGL material group to the 60% interpretive cut-point.

Table 3: Results Showing Subgroup Mean Difference Compared to the Cloze Interpretive Cut-Points¹

	<i>M</i> difference	<i>t</i> -value	<i>df</i>	<i>p</i> -value ⁷	Effect size ⁸
Compared to 40% Cut-point (Somewhat Comprehensible) ³					
Cardinal & Seidler Study No College Degree ⁴	4.59	1.658	18	.114	0.38
Present Study 11th RGL ²	10.81	5.475	11	< .001	1.58
Compared to 60% cut-point (Fully Comprehensible) ⁶					
Cardinal & Seidler Study No College Degree	-15.41	5.565	18	< .001	1.28
College Degree ⁵	-1.14	0.605	36	.549	0.09
Present Study 11th RGL ²	-9.19	4.654	11	< .001	1.34
8th RGL ²	5.94	5.936	7	< .001	2.09

Notes. (1) Difference scores are by percentage points. The minus sign was used on values for the *M* difference to indicate a negative difference. (2) RGL stands for reading grade level. (3) Difference was not tested against the 40% cut-point for the "college degree group" and "8th RGL group" because they were much closer to the 60% cut-point, per their descriptive statistics. (4) Individuals with a high school diploma and who completed some college courses. (5) Individuals who earned a bachelor's and master's degree. (6) Bonferroni adjustment for two total comparisons (i.e., $\alpha = .10/2 = .05$). (7) Bonferroni adjustment for four total comparisons (i.e., $\alpha = .10/4 = .025$). (8) Exact *p*-values reported. (9) Effect size measure = Glass's Δ . Interpretive cut-points: 0.10 = small/minimal, .50 = medium/typical, .80 = large/substantial.

For the 11th RGL material group, comprehension was equivalent to the no college degree group on average. Based on the descriptive statistics, we suspected comprehension scores of the 11th RGL material group would have been statistically larger than the no college degree group. This outcome was not observed, however. For more detail, refer to Table 4.

4 Discussion

The purpose of the present retrospective and comparative analysis study was to investigate the generalizability of the Cardinal and Seidler (1995) study findings, which suggested lay adult's ability to comprehend one physical activity promotion brochure was inadequate (i.e., not capable to somewhat capable, on average), for a wide range in educational attainment (Cardinal & Seidler, 1995). Within the present study, we found considerable overlap between our findings and those reported by Cardinal and Seidler. Material written above the established 8th RGL would likely result in inadequate comprehension in lay adults without considerable effort and supplemental instruction (Miller & Stine-Morrow, 1998; Ng et al., 2019). Specific to our study, we confirmed reducing the reading grade level may improve comprehension of physi-

cal activity promotion material, but only partially if the text remains above the 8th RGL cut-point. Within this section, we discuss the implications of our findings and present recommendations for future research.

One implication concerns the ecological validity of mediated interventions to promote physical activity. Mediated interventions are strategies to support behavioral change without interpersonal interaction with professionals. Generally, mediated print- and web-based interventions have been shown to increase baseline physical activity levels in sedentary and somewhat active adults, across a wide range in age, with effects sustained post-intervention for weeks to months (Marcus et al., 2007; Müller & Khoo, 2014; Parrott et al., 2008). The present study's findings underscore the need to ensure all recipients understand mediated messages to fully understand behavioral prompts, suggested strategies, and other guidelines (Harrison et al., 2019; Zhang, 2014). According to cognitive load theory, working memory is crucial for the accurate and appropriate application of health-related information received, including from print and online media (Wilson et al., 2012). The more mental energy needed to comprehend information (e.g., to perceive and decode messages), the less energy is available to integrate message information with prior knowledge or identify ways to effectively apply message information to health-related deci-

Table 4: Results Showing Mean Difference between Subgroups¹

	<i>t</i> -value ²	<i>df</i>	A priori <i>p</i> -value	Adjusted <i>p</i> -value ³	<i>p</i> -value observed	Effect size ⁴
8th RGL Group Mean Cloze Score (% Points) versus Remaining Subgroups						
No college degree	7.251	22.041	.10	.017	< .001	2.06
College degree	3.317	42.002	.10	.017	.002	.67
11th RGL	6.835	15.743	.10	.017	< .001	2.69
11th RGL Group Mean Cloze Score (% Points) versus Remaining Subgroups						
No college degree	1.829	28.782	.10	.017	.078	.59
College degree	-2.948	32.064	.10	.017	.006	.76
8th RGL	-6.835	15.743	.10	.017	< .001	2.69

Notes. (1) Equal variance between groups not assumed for any analysis (i.e., $p < .05$); corrected *t*-test used in each comparison. (2) Since mean difference values are not reported here, minus signs were used on *t*-values to indicate direction, if referent group mean score was smaller (e.g., 11th RGL group). (3) Bonferroni adjustment for six total comparison (i.e., 3 per 8th RGL group, 3 per 11th RGL group). (4) Effect size measure = Hedge's *g*. Interpretive cut-points: 0.10 = small/minimal, .50 = medium/typical, .80 = large/substantial.

sions and behaviors (Wilson et al., 2012).

It is not clear how often and the ways in which the literacy demand of educational materials used in physical activity promotion interventions are pre-tested before their wide use (Thomas & Cardinal, 2018). However, pre-tested physical activity promotion materials may have a greater chance of being understood by a diverse group of lay adults across clinical and non-clinical settings (Cardinal, 1995; Vallance et al., 2008). The caveat is that messages and material design suit the cultural habits and prior knowledge of end-users. Beyond making messages salient by matching them to motivational readiness for behavior change or the cultural values of end-users (Cardinal et al., 2002; Morgan et al., 2016), our findings underscore the need to pre-test messages for predictability. Specifically, we observed the 8th RGL mock material published by Thomas et al. (2023a) had worse comprehensibility than its 11th RGL material counterpart. Although the 8th RGL mock material was suspected of having areas for improvement, as a case material for teaching lay communication techniques, the research team likely did not expect our findings. Unlike their 11th RGL material, their 8th RGL material was not pilot-tested for face validity with end-users. Doing so could have helped the research team correct any awkward phrases or vocabulary that may have held back comprehension, as suggested by the present study's findings.

Finally, the present study's findings suggest that literacy-sensitive research should be a focus of kinesiology research (Smith et al., 2022a). Literacy-sensitive research is a methodology to ensure positive intervention outcomes (Kim & Lee,

2016), regardless of a person's literacy ability (e.g., to perceive and process new and unfamiliar information) or regardless of a person's health literacy level (e.g., ability to understand health guidelines and instructions specific to a person's life situation or health goals). Our findings suggest that individuals with basic and high literacy skills could achieve the same level of comprehension if health materials are (appropriately) written at/below the 8th RGL cut-point. Taylor (1953) argues that, theoretically, the cloze procedure was designed to compare the readability of different topics of material so long as there was cultural overlap between end-users. Our comparative analysis suggests that if the brochure written at a graduate school reading level was (appropriately) written at/below the 8th RGL cut-point, then adults with a high school degree or higher would likely achieve equivalent comprehension of such material and would not require supplemental instruction. These findings mirror literacy-sensitive research interventions focused on diabetes management and health-related lifestyle changes in clinical populations (Kim et al., 2004; Rothman et al., 2004). In fact, reviews of health literacy research suggest adults with low/limited literacy skills could achieve similar gains from health interventions when lay communication principles are met (and health behavior theory is utilized; Kim & Lee, 2016; Sheridan et al., 2011). The extent to which this applies to physical activity promotion intervention within and outside clinical settings remains to be seen (Thomas, 2019). Few studies in kinesiology may examine the relative effectiveness of their interventions for individuals with low, basic, or proficient

(health) literacy skills (Eckman et al., 2012; Lam & Leung, 2016), let alone investigate which design features may level the playing field for all participants (Espigares-Tribo & Ensenyat, 2021; Lattimore et al., 2010).

4.1 Future Research Recommendations

The limitations of the present study and discussion of its findings provide several avenues for future research.

First, this study's comparative analysis was somewhat underpowered for detecting if the mock test material had greater comprehensibility than the brochure studied by Cardinal and Seidler (1995) (for greater discussion, see Thomas et al., 2023b). If the present study's findings are replicated, they could be combined to produce a larger sample for comparison against the Cardinal and Seidler subgroups (Cardinal, 1993). Towards that end, studies replicating the present study are advised to check the predictive validity of the cloze forms first, then systematically adjust the 8th RGL material if needed (followed by a retest). This systematic formative assessment into how well the test materials (i.e., cloze forms) function before using them within the main study would give insight into what may work when attempting to edit health-related material to meet reading grade level recommendations or other suitability standards for effective lay communication (Doak et al., 1996a; Espigares-Tribo & Ensenyat, 2021). For example, our results suggest that text predictability is crucial (Taylor, 1953).

Second, future research should test if the present study's findings can be replicated in large and diverse samples (Halperin et al., 2018). Specifically, we recommend that researchers test if our revised material written at the 8th-grade reading level (measured by the SMOG formula) has greater comprehension than the materials developed by Thomas and colleagues (2023a). Refer to Supplemental Content File 1 to obtain the test material used in this study (i.e., the revised 8th grade reading level, the original 8th grade reading level, and the 11th grade reading level, mock material). Additionally, more systematic approaches could be used to pilot test those materials (Thomas et al., 2023c), including asking end-users to rate the materials on their appropriateness and clarity in addition to how realistic they look (Cardinal, 1995; Espigares-Tribo & Ensenyat, 2021; Vallance et al., 2008). Several studies have published their

methodologies for systematically pilot testing their intervention material with lay end users (Cardinal, 1995; Espigares-Tribo & Ensenyat, 2021; Vallance et al., 2008), which could be used to further analyze (and pilot test) the mock material used in the present study. Moreover, adapting these pilot testing methods as a student learning activity by college and university instructors should provide students with more opportunities to achieve significant learning on lay communication techniques (Kamp & Thomas, 2022; Ross & Thomas, 2022).

Finally, our discussion brought to light a need for future research in kinesiology to examine the extent to which physical activity promotion researchers disclose/report testing the suitability (and usability) of their intervention activities or materials before implementation (Watson & Thomas, 2024). We suggest parsing such work into two projects, one focused on interpersonal or combined interventions and another on mediated interventions. Wilson et al. (2012) adapted procedures for a systematic review to perform a comparative synthesis of health research testing the relative effectiveness of print and multimedia material in promoting health literacy and health behavior. We encourage the systematic replication of their methods to studying mediated physical activity promotion interventions, and interpersonal interventions, in kinesiology (APA, n.d.). Moreover, we recommend future review studies investigate the degree to which researchers conducting physical activity promotion interventions report outcomes by health literacy level. While several literacy-sensitive, review studies contain reports showing (or implying) favorable behavioral health outcomes regardless of health literacy level in the physical domain (e.g., self-reports for exercise or physical activity, HgbA1c measures; Kim & Lee, 2016; Sheridan et al., 2011), these studies likely are not representative of intervention studies in kinesiology (Hosseinzadeh et al., 2022).

4.2 Conclusion

The present study was a retrospective and comparative analysis of the Cardinal and Seidler (1995) study directly measuring lay comprehension of physical activity promotion material. The results of our study suggest physical activity promotion material written above the 8th-grade reading level (measured using the SMOG formula, McLaughlin, 1969) would likely disadvantage lay adults, especially those without a college degree. Furthermore, the results suggest this equity issue can be mit-

igated, but revised health-related material should be pilot-tested with end-users before their wide dissemination. Discussion of these findings brought to light a concerted need to evaluate the kinesiology intervention literature in order to understand the extent materials and activities focused on physical activity promotion are tested for suitability (and usability) for adults with varied levels of health literacy (e.g., low, basic, proficient; Thomas et al., 2022a; Wilson et al., 2012). Towards that end, we concluded our discussion with recommendations for future research, including the suggestion to systematically replicate the present study—including its pilot testing procedures.

Conflict of Interest

The authors have no conflicts of interest to declare.

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