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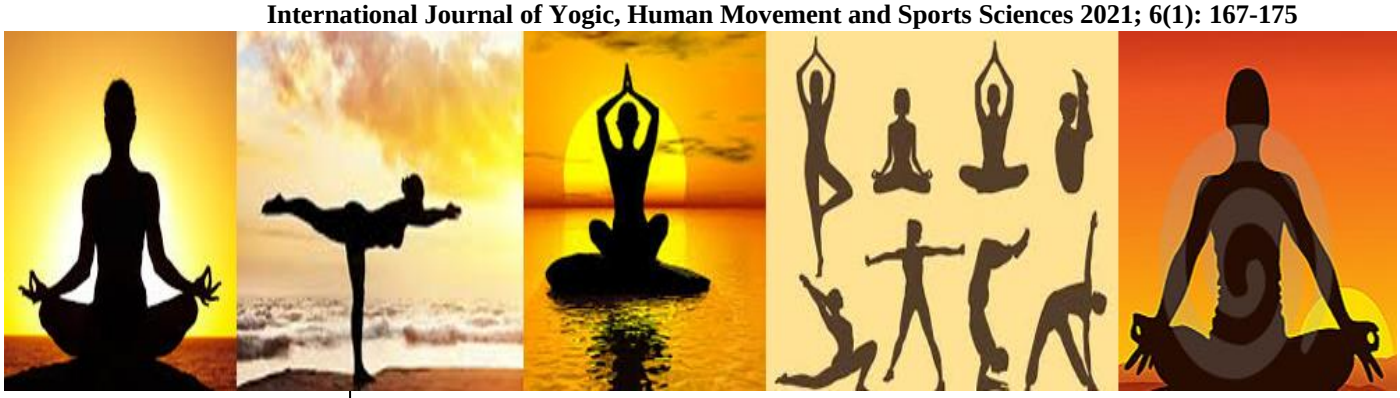

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A literature review on the physiological and psychological effects of labyrinth walking

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Abstract
To the author's knowledge, the present literature review is the first to describe the physiological and psychological effects of labyrinth walking. Relevant literature was identified in Google Scholar to answer three research questions. First, how is labyrinth walking defined, and what are its key features? Second, what is the focus of the literature about labyrinth walking? Third, what are the physiological and psychological effects of labyrinth walking? This literature review revealed that labyrinths are paths that curve or wind to create a circular, square, or rectangular pattern. The paths have only one entrance that begins a unidirectional path toward the center, which is the same path to the exit. The literature about labyrinth walking focuses minimally on the physiological effects and almost exclusively on the psychological effects. Labyrinth walking has unclear physiological effects but mostly positive psychological effects. People with different demographic characteristics from several countries reported positive emotions, sensations, and thoughts during and after labyrinth walking. Methodologically rigorous studies, especially randomized controlled trials, are needed to determine if labyrinth walking objectively improves physiological and psychological outcomes, especially outcomes related to cardiovascular disease. Two qualitative questions that should be answered by future studies are why people enjoy labyrinth walking and whether the labyrinth walking motivates people to achieve higher levels of physical activity.

Keywords: meditation, mind-body exercise, mindfulness, spiritual health, walking meditation

Introduction
Globally, the leading causes of death are chronic lifestyle diseases. The chronic lifestyle disease that causes the most deaths is cardiovascular disease (CVD), an umbrella term for many diseases of the heart and blood vessels. In 2016, in the United States (U.S.), CVD caused 840,000 deaths [1]. A key risk factor for developing and dying from CVD is being sedentary [2]. To mitigate the consequences of being sedentary, adults should complete 150 minutes of moderate-intensity physical activity per week [3, 4]. A 2020 survey found that over 15% (range: 17-48%) of U.S. adults across all states and territories were physically inactive during leisure time [5]. Most adults could increase their physical activity level by walking. Walking does not require special skills and is free, feasible in diverse settings, and improves CVD risk factors [6]. For these reasons, walking is a promising physical activity that may reduce the burden of CVD in the United States.

To be widely adopted, physical activities should be accessible to much of the general population. Walking can be customized to each person's needs by adjusting the location, terrain, duration, and speed. Altering these variables changes the physical demand and people's sensory experiences of walking. The physical demand of walking is one barrier that discourages people from participating. Initial and long-term participation may increase if walking is structured to create a positive sensory experience. Creating a positive sensory experience is the focus of labyrinth walking. During labyrinth walking, a person walks a painted or projected path, or a path created by objects such as rocks or tape. The path into the labyrinth leads the person to the center and is the same path used to exit the labyrinth. While walking the path, the person should not be distracted by electronic devices or other people. Avoiding distraction aligns with the purpose of labyrinth walking, which is to promote contemplation [7]. While labyrinth walking is a physical activity focused on creating a positive

sensory experience, few published papers have described the activity. To the author's knowledge, no published paper has reviewed the physiological and psychological effects of labyrinth walking. A literature review on this topic would suggest whether labyrinth walking favorably affects physiological and psychological outcomes, especially outcomes related to CVD. Filling this gap would inform health professionals of whether labyrinth walking should be recommended to improve health and reduce the burden of CVD.

To describe the literature about the physiological and psychological effects of labyrinth walking, the author created three research questions: 1) How is labyrinth walking defined, and what are its key features? 2) What is the focus of the literature about labyrinth walking? And 3) What are the physiological and psychological effects of labyrinth walking? To answer these three research questions, the author conducted this literature review by using the following methods.

Methods

To expediently collect and appraise the literature about labyrinth walking, one online database, Google Scholar, was searched. Google Scholar is an extensive, free database that returns peer-reviewed academic journal articles and is often used by academics to conduct literature reviews. For the present literature review, the search for and screening of articles followed a structured protocol.

The structured protocol was based on eligibility criteria. To be included in the present review, articles needed to be indexed in Google Scholar, written in English, and include information on labyrinth walking by humans. Preferably, but not mandatorily, the articles would discuss the effects of labyrinth walking on at least one physiological or psychological outcome, especially outcomes related to cardiovascular health. The articles did not need to be reports of research studies. However, reports of observational or interventional research studies were eligible. The research studies could have sampled any human population and used any study design in any physical setting (e.g. indoor and outdoor labyrinths). Interventional research studies were included, even if they did not have a comparison or control group. Articles were excluded if they were not indexed in Google Scholar or written in English. Articles were also excluded if they did not sample a human population. No limits on publication date were set in Google Scholar.

A notable feature of Google Scholar is that it returns three types of results other than articles: citations, patents, and books. The check boxes next to citations and patents were unchecked to prevent these records from diluting the concentration of articles in the search results. A checkbox to remove books was not available, so books that appeared in the search results were ignored. Another notable feature of Google Scholar is that it provides only the first 1,000 search results (100 pages of 10 results each), regardless of the total number of results. For this reason and the solo, expedited nature of this review, only the first 500 results were searched and screened. These results were obtained with the broad search term: "labyrinth walk OR labyrinth walking AND health OR cardiovascular." This broad search term was intended to capture as many relevant articles as possible. The articles appearing in the results were screened by their titles. Next, the articles were screened by their abstracts and then their full texts. To expedite the search and screening protocol, the references of the included full texts were not searched to find more relevant articles. This review was also expedited by omitting a formal evaluation of the included articles' risk of bias and quality.

Results and Discussion

The search in Google Scholar on 4/1/2021 returned 52,700 results in total. Of the first 500 results of the 1,000 viewable results, only 29 results were included by title. No results were included by title after page 10 of the results. None of the 29 results were duplicates. Screening the 29 results by their abstracts revealed that one result was a journal article unrelated to labyrinth walking and eight results were not journal articles (two conference proceedings, one doctoral dissertation, one master's thesis, one magazine article, one non-academic journal article, and two non-journal reports). Those nine results were excluded, which left 20 journal articles. Screening the 20 journal articles by their full texts revealed that one article was an incomplete source (only the first page was available) and one article was not about labyrinth walking. Those two articles were excluded. The remaining 18 full-text articles were included in this review (Figure 1). Most of the articles are cited and discussed only in the text of the Results and Discussion because they did not describe research studies. Seven of the articles are cited and discussed in the text and Table 1 because they described research studies of labyrinth walking (i.e. they were study reports).

Research Question 1

The first research question asked, "How is labyrinth walking defined, and what are its key features?" The first step to answering the question was to define a labyrinth. A labyrinth is a path that curves or winds to create a circular, square, or rectangular pattern [7, 8]. Labyrinths are unicursal, meaning they only have one entrance that begins a unidirectional path toward the center [7-10]. The path into the labyrinth does not branch and is the same path used to exit [10] (Figure 2). These features distinguish labyrinths from mazes. Mazes are multicursal, meaning they may have more than one entrance, each which begins paths that may misdirect and lead to dead ends [1-3]. Mazes are thus intentionally difficult to traverse [10], which is made more difficult by high walls that block the view of the different paths [9]. Beside their unicursality, labyrinths are defined by the number of paths around their center, called circuits [8]. For example, a labyrinth with seven circuits requires a person to walk around the center seven times before reaching the center (Figure 2). Across the globe, labyrinths are diverse in their overall designs and numbers of circuits. However, the two most popular designs are the classical 7-circuit design (Figure 2) and the Chartres Cathedral 11-circuit design [11] (Figure 3). These two designs and nearly all others have three distinct features [11] (Figure 4). The first feature is a spiral that symbolizes growth and transformation. The second feature is a circle that encircles the spiral and symbolizes unity and wholeness. The third feature is a cross or quadrangle that symbolizes orientation and structure [11]. Most of the articles in this review described unicursal labyrinths with these three features and various numbers of circuits.

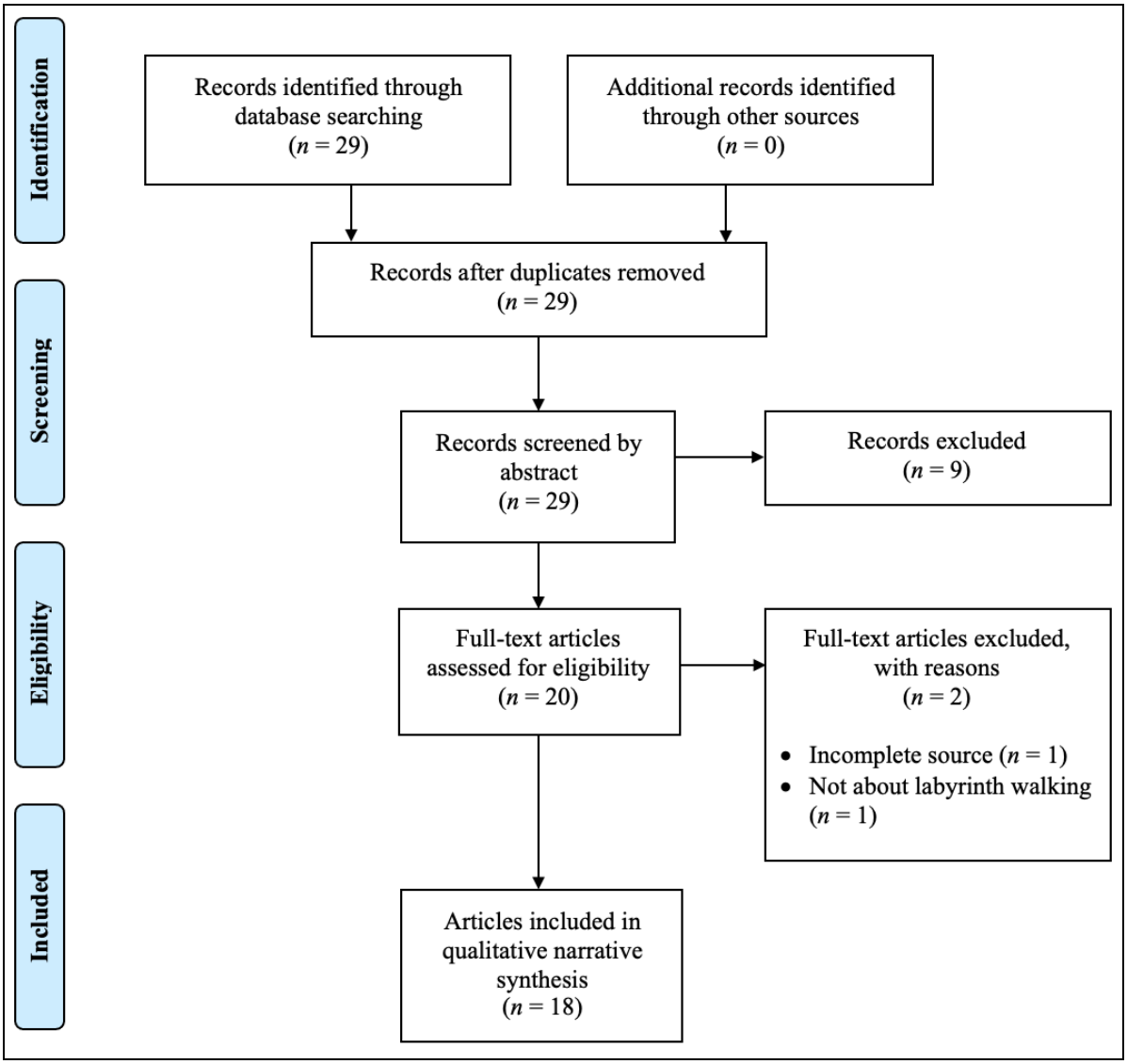

Fig 1: The flow of the search and screening protocol.

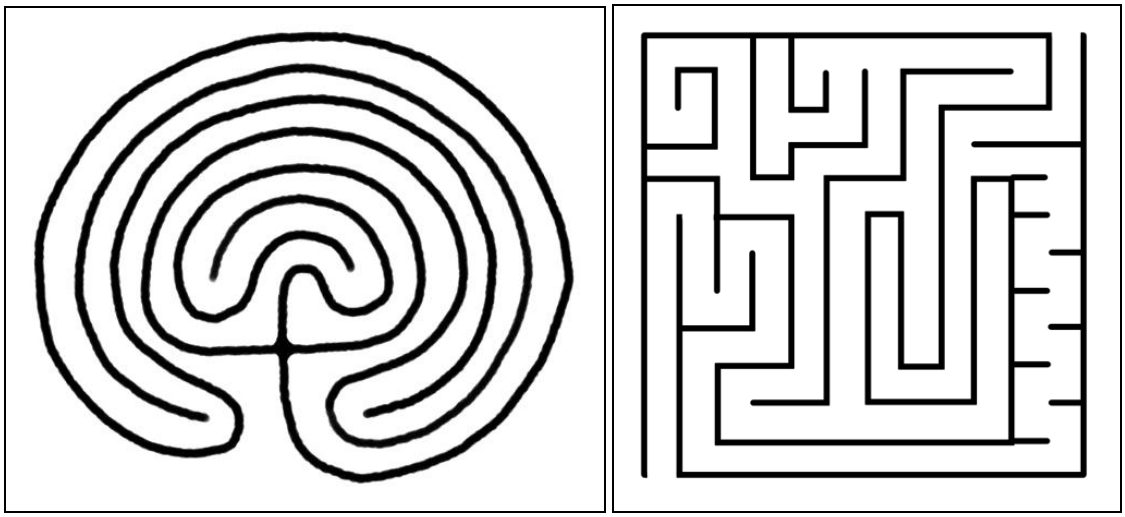

Fig 2: Examples of the classical 7-circuit unicursal labyrinth (left) and a maze (right). Note that the labyrinth does not have dead ends and has only one entrance/exit that leads to the center. The maze has dead ends and two entrances/exits that lead to each other instead of a center location.

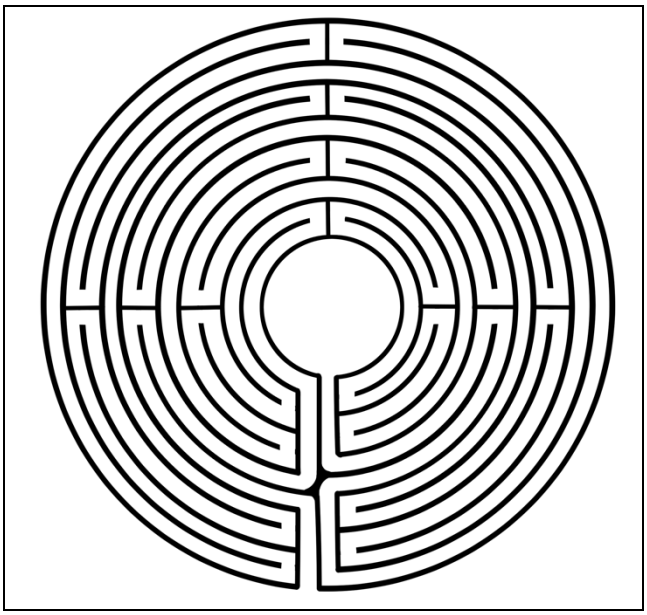

Fig 3: Diagram of the Chartres Cathedral 11-circuit design.

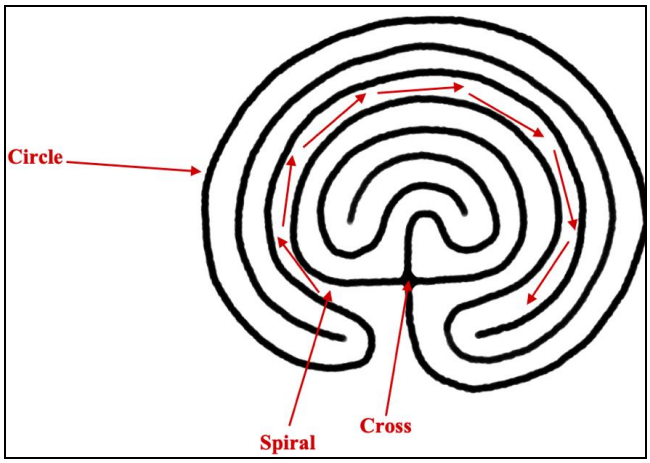

Fig 4: The designs of nearly all labyrinths have three features: a spiral, circle, and cross or quadrangle (identified by the red arrows).

After defining labyrinths, the next step was to define labyrinth walking. Defining labyrinth walking began with studying its history that dates back at least 4,000 years [12]. Ancient Chinese, Grecian, Indian, Peruvian, and Spanish cultures built labyrinths [7]. This cultural phenomenon also occurred in Scandinavia and mainland Europe, from the Middle Ages to the 17th century, and among indigenous tribes in North America [7]. People living in different centuries and cultures have built labyrinths to serve different purposes. Modern Westerners, especially in the United States, have grown interested in labyrinths since Reverend Dr. Lauren Artress popularized them in the early 1990s [7, 11, 13]. The popularity of labyrinths may be growing because of modern Westerners' desire for more creativity and intuition, community, mind-body-spirit integration and intimacy, deeper spirituality, and connectedness with the human soul [11]. These benefits are supposedly obtained from walking a labyrinth [11]. For this reason, labyrinth walking is commonly defined as a meditative and spiritual experience [7, 14, 15] that activates the right-brain [7, 14] and facilitates "contemplation, reflection, and transformation" (p. 667) [7]. Because labyrinth walking supposedly fosters creativity and intuition, the activity has been described as a mirror that reflects where people are in life [14]. The parallel between the labyrinth and life's path may help people determine their own future, cope with hardship, and feel joy [13, 14].

As its key features, labyrinth walking usually has four phases: releasing, receiving, returning, and journaling [7]. The releasing phase begins upon entering the labyrinth and continues during the walk toward the center. Arriving at the center and spending time there comprises the receiving phase. Exiting the center and walking toward the exit comprises the returning phase. After reaching the exit, reflecting on the experience and writing one's thoughts and feelings comprise the journaling phase [7]. The journaling phase is omitted in some descriptions of labyrinth walking, which describe only the releasing, receiving, and returning phases [12]. Creating calmness and peacefulness during the phases may be facilitated by playing calming background music, but silence is also acceptable [10]. It is also acceptable to not know the phases of labyrinth walking because there are no right or wrong approaches [15]. A person should walk a labyrinth without trying to make the experience unfold in a certain way [15]. It is unclear how many people walk labyrinths, what percentage of them know the phases, and how people approach and experience labyrinth walking. Yet modern labyrinths are widespread. The leading database for locating labyrinths, The World-Wide Labyrinth Locator, contains over 6,000 registered labyrinths in over 85 countries, 4,523 of which are in the United States as of April 2021 [16]. The scarcity of information about labyrinth walking despite the abundance of labyrinths is paradoxical. The scarcity also highlights the importance of the second research question.

Research Question 2

The second research question asked, "What is the focus of the literature about labyrinth walking?" Identifying the focus of the literature about labyrinth walking was important because it clarified peoples' experiences with labyrinths (i.e. the setting, design, and purpose of the labyrinths). In this review, the literature means journal articles. Because the next section addresses articles about research studies (research question 3), this section only discusses the focus of articles that were not about research studies.

The articles that were not about research studies often speculated about the health benefits of labyrinth walking. Without firm evidence, the articles claimed that labyrinth walking causes a relaxation response that lowers blood pressure, slows breathing, and eases chronic pain and insomnia [14, 17]. Besides making these claims, the articles discussed the settings in which labyrinths are used. Labyrinths are commonly used for therapy in diverse health care settings. These settings include cancer treatment centers, domestic violence shelters, healing gardens, nursing facilities, and major medical centers, including Johns Hopkins Medical Center [9, 14, 17]. Centers for end-of-life care also have labyrinths [12]. In the English county of Kent, Pilgrims Hospice provides labyrinths as palliative and spiritual care to patients and their caretakers, families, staff, and volunteers [12]. These people report that labyrinth walking brings them emotional and spiritual calm and helps them cope with grief and make better decisions [12]. These benefits may be experienced by both religious and irreligious patients. Whereas a religious patient can walk a labyrinth as a path of prayer for spiritual enlightenment, an irreligious patient can walk a labyrinth for secular meditation [12]. In either case, labyrinth walking may not require actually walking. A hospice patient in a wheelchair who was pushed through a labyrinth by his or her partner reported feeling awe, inner calm, and love[12]. Beyond reporting the benefits of labyrinths,

Pilgrims Hospice has shown that labyrinths are feasible in healthcare settings [12] where money and space are limited. These limitations are avoided with fabric labyrinths. This type of labyrinth is feasible because it is inexpensive and customizable. The design, fabric, and size can be chosen to accommodate small or large indoor and outdoor spaces in health care settings. When those spaces are needed for other reasons, the fabric labyrinths can be rolled up and stored.

Another type of labyrinth that is also inexpensive, customizable, and removable is masking-tape labyrinths. Masking-tape labyrinths are frequently used in another health care setting, marriage and family therapy[10], for two reasons. The first reason is that therapists can have couples or family members consider issues and each other's perspectives as they walk the labyrinth in silence together. After the couples or family members have contemplated the issues and perspectives and exited the labyrinth, the therapist can facilitate a discussion about everyone's labyrinth experiences and potential solutions to the issues [10]. The second reason is that, because masking-tape labyrinths are quicker to build than stone labyrinths (takes 20-30 minutes), therapists can have couples or family members build a labyrinth together[10]. Watching couples or family members build a labyrinth together informs the therapist about their social dynamics[10]. Having a better understanding of their social dynamics, the therapist can implement strategies to promote healthier relationships. If space allows, the couples and family members may even wish to create and use their own labyrinths at home to resolve conflict or difficult conversations [10]. These examples show labyrinths are versatile tools that can be used in various therapy settings. The versatility also gives people flexibility in processing their thoughts and emotions related to family issues [10] and anxiety, depression, bereavement, grief, life transitions, and substance addiction [13]. People can use labyrinths unguided or guided by a therapist, alone or with partners or family members.

The versatility of labyrinths makes them useful beyond health care settings. Another setting in which labyrinths are used is higher education. Over 100 colleges and universities worldwide have labyrinths on their grounds [16]. Some of the labyrinths have been used by college counseling centers for outreach. In 2009, the Counseling Center of Central Michigan University introduced a fabric labyrinth on campus [11]. The labyrinth was made available to the campus community as part of the Center's programming to prevent mental health problems and foster healthy development. Faculty, staff, and students used the labyrinth for faculty training, multicultural programs, wellness programs, and student group activities [11]. These programs made the labyrinth popular on campus, so much so that some faculty members used the labyrinth in their classes. Faculty introduced labyrinth walking to the first-year experience (a course for incoming freshmen) and courses for incoming non-traditional students. The intent of labyrinth walking in these courses was to reflect the students' journey along an unfamiliar path as they transitioned into higher education. The students were encouraged to walk the labyrinth while reflecting on what/whom they would take on their journey, what/whom they would leave behind, and who the helpers along their journey would be. Then students journaled about their respective experiences and shared them among the class[11]. A similar approach to using labyrinths with college students had been previously implemented for nursing students at a different university.

In 2004, the University of Texas' School of Nursing built a labyrinth modeled on the 13th-century Chartres Cathedral [17]. The labyrinth was intended to help nursing students meditate, introspect, and gain a global perspective on their practice [17]. The students had to listen to an article about labyrinths, walk the labyrinth, and journal about whether they thought the experience was useful or could be translated into their nursing practice. In one nursing cohort, the experience was considered useful and translatable into their nursing practice by 20 of 25 students (80%). Some students felt the experience mirrored life because it followed a confusing and winding path but could be completed by slowing down and persevering[17]. Some students also felt the labyrinths reduced their stress and helped them relax despite the demands of their family, school, and work [17]. These findings show that nursing students who walked labyrinths in an academic setting had positive experiences similar to the positive experiences of patients who walked labyrinths in healthcare settings.

The articles about labyrinth walking discussed so far in this review were not research studies. Research studies that include experimental methods and control the setting, type of labyrinth, and walking procedure are required to verify that labyrinth walking causes physiological and psychological changes that benefit participants. For this reason, the next section of this review discusses articles about research studies of labyrinth walking.

Research Question 3

The third research question asked, "What are the physiological and psychological effects of labyrinth walking?" The main findings were that the physiological effects of labyrinth walking are unclear and there are only limited and inconclusive data. These effects received almost no attention in the articles included in this review. Instead, the articles primarily focused on the psychological effects of labyrinth walking (i.e. how the behavior affects thoughts and emotions). Consequently, this section briefly discusses the physiological effects and then primarily discusses the psychological effects (Table 1).

Table 1. Research studies on the physiological and psychological effects of labyrinth walking.

Authors, Year (Country)	Study Design	Participants	Labyrinth Walking	Main Findings
Lizier *et al*., 2018 (Brazil) [18]	Cross-Sectional, Uncontrolled; Qualitative and Quantitative	*n* = 30; convenience sample of adult members of an integrative therapy institute 91% female; 41% aged 50-59 yrs; 73% completed higher education	Session(s): One Walking Duration: 25 min Labyrinth Design: Not reported	Participants reported thinking of: ● Family and their phase of life (48%) ● Being in a safe place (38%) ● Troubling thoughts (14%) 21-90%[a] of participants reported emotional distress about the time needed to walk through the labyrinth 14-17%[a] of participants reported

				losing track of space and time
Behman *et al*., 2018 (Canada) [19]	Cross-Sectional, Uncontrolled; Qualitative and Quantitative	*n* = 25; convenience sample of youth and young adults at a Canadian Children's Hospital 84% female; aged 19 ± 3 yrs[b] (Range: 12-24 yrs)	Session(s): One Walking Duration: Not reported Labyrinth Design: Projected light labyrinth (path created by white light, and walls created by shadows); 5-circuit classical pattern	RSA: ↑ after exiting the labyrinth vs. baseline sAA: ↑ while exiting the labyrinth vs. baseline Participants reported: ● Their experiences as calming (76%) and relaxing (40%) ● Feeling increased awareness (72%) ● Feeling peaceful and less stressed/anxious (44%) ● Feeling more stressed (20%)
Boardman *et al*., 2017 (United States) [20]	Longitudinal; Controlled; Quantitative	*n* = 26; convenience sample of employees at an orthopedic medical center 96% female; aged 46 yrs[b] (Range: 20-62 yrs)	Session(s): Three per week for eight weeks Walking Duration: 10-15 minutes per session Labyrinth Design: 7-circuit classical pattern (width = 25 feet)	Stress[c]: No changes from pre- to post-intervention After labyrinth walking, participants reported feeling[d]: ● Less agitated (57%) ● Less anxious (44%) ● Less stressed (56%) ● More peaceful (57%) ● More quiet (53%) ● More relaxed (50%)
Zucker *et al*., 2016 (United States) [21]	Cross-Sectional; Controlled; Qualitative and Quantitative	*n* = 45; convenience sample of library users at an academic library (undergraduate and graduate students, libraries, and faculty) 89% female; aged 36.4 ± 17.4 yrs[b] (Range: 19-67 yrs)	Session(s): One Walking Duration: Not reported Labyrinth Design: Varied by participant; Self-selected projected design (Sparq mindfulness tool)	BP: ↓ systolic BP in treatment and control groups (no difference between groups); no changes in diastolic BP HR: ↓ in treatment and control groups (no difference between groups) Relaxation[e]: After labyrinth walking, ↑ relaxation, peacefulness, and reflection; ↓ anxiety, stress, and agitation
Heard *et al*., 2015 (Canada) [22]	Longitudinal; Uncontrolled; Qualitative	*n* = 12; convenience sample of adults who were diagnosed with serious and persistent mental illness and were residing at a forensic mental health care facility 8% female; aged 40 yrs[b] (Range: 21-60 yrs)	Session(s): Not reported (Walking the Labyrinth program) Walking Duration: Not reported Labyrinth Design: 7-circuit Chartres and 11-circuit Chartres Cathedral	Overarching Themes in Participants' Experiences: ● Reflection and focus ● Relaxation ● Reduced stress ● Peace ● Accomplishment or success ● Escape ● Meaning making
Zucker & Sharma, 2012 (United States) [23]	Longitudinal; Uncontrolled; Quantitative	*n* = 14; convenience sample of adult men incarcerated in a Massachusetts county jail 0% female; aged 34 ± 11 yrs[b]	Session(s): Six, 90-min sessions across six weeks; Each session comprised a lecture, labyrinth walking, and journaling Walking Duration: Not reported Labyrinth Design: 11-circuit Chartres Cathedral	BP: No tests of statistical significance Quality of Life[f]: No tests of statistical significance
Sandor & Froman, 2006 (United States) [24]	Cross-Sectional; Controlled; Quantitative	*n* = 25; convenience sample of apparently healthy adults from the communities of Galveston, Texas (*n* = 15), and San Francisco, California (*n* = 10) 80% female; age range: 18-62 yrs	Session(s): One Walking Duration: 22.5 min (Range: 15-30 min) Labyrinth Design: 11-circuit Chartres Cathedral[g]	No tests of statistical significance for any pre-post intervention differences in outcomes BP: No change after labyrinth walking (near-zero ES) HR: ↑ after labyrinth walking (small ES) RR: ↑ after labyrinth walking (small ES) Affect[h]: ↑ positive affect (small ES) and ↓ negative affect (moderate ES) after labyrinth walking

[a]These ranges indicate that different percentages of participants reported the outcome during the different phases of labyrinth walking (while entering, exiting, or both entering and exiting); [b]mean or mean ± standard deviation; [c]Measured by the Perceived Stress Scale, Copenhagen Psychosocial Questionnaire II, and salivary cortisol; [d]The percentages indicate the percentage of participants in the labyrinth walking group who reported each feeling in the Labyrinth Walk Questionnaire; [e]Measured by the Bizzell Labyrinth Questionnaire; [f]Measured by the Short-Form Health Survey Version 1; [g]Two labyrinths with the same design but different settings were used (the outdoor labyrinth at William Temple Episcopal Center in Galveston, Texas, and the indoor labyrinth at Grace Cathedral in San Francisco, California); [h]Measured by the Positive Affect Negative Affect Schedule; *n*: sample size; yrs: years; min: minutes; RSA: respiratory sinus arrhythmia (measure of heart rate variability); sAA: salivary alpha-amylase; BP: blood pressure; HR: heart rate; ES: effect size; RR: respiratory rate

One of the first research studies to evaluate the physiological effects of labyrinth walking was conducted by Sandor & Froman (2006) [24]. These researchers measured the outcomes of blood pressure, heart rate, and respiratory rate in participants before and after walking a labyrinth. Because of the small sample size, pre-post-intervention differences in the outcomes were not analyzed for statistical significance. Neither raw nor summary pre-post data were provided. Instead, effect sizes were given as Cohen's *d*. The blood pressure data were confounded and thus not useful because some participants smoked cigarettes right before or after labyrinth walking. The small effect sizes for heart rate (d = 0.14) and respiratory rate (d = 0.37) suggest that both outcomes increased marginally across the walk[24]. The increases in heart rate and respiratory rate suggest that the participants were more physiologically aroused after labyrinth walking than before. However, the nicotine from cigarettes could have caused the physiological arousal among participants who smoked before or after labyrinth walking.

In another study, the effects of labyrinth walking on physiological arousal were evaluated in students, librarians, and faculty at an academic library. Zucker *et al*. (2016) measured the pre- and post-intervention blood pressure and heart rate of participants in a treatment and control group [21]. Participants in the treatment group selected a labyrinth design and walked a projected labyrinth having the selected design. Participants in the control group did not walk and, instead, read posters about the cultures from which the different labyrinth designs came[21]. Whereas diastolic blood pressure did not change after the intervention in either group (p = 0.09), systolic blood pressure and heart rate significantly decreased in both groups (p = 0.01 and p = 0.049, respectively). The mean differences in systolic blood pressure and heart rate did not significantly differ between the groups (systolic blood pressure: p = 0.63; heart rate: p = 0.18) [21]. These findings suggest that labyrinth walking did not lower physiological arousal more than reading about the cultures from which different labyrinths came.

Blood pressure and heart rate are just two measures of physiological arousal. Other investigators have evaluated cardiac and chemical measures indicative of short-term arousal of the autonomic nervous system. Behman *et al*. (2018) had Canadian youth and young adults at a Canadian Children's Hospital walk a projected light labyrinth [19]. The researchers calculated changes in participants' respiratory sinus arrhythmia (RSA) and salivary alpha-amylase (sAA) adjusted for flow rate. The RSA is a measure of heart rate variability (variability in the length of the R-R interval of an electrocardiogram) that represents the parasympathetic/rest-and-digest activity [19]. The sAA level in a sample represents the sympathetic/fight-or-flight activity in the five minutes before the sample was taken (because sAA secretion is delayed after a stimulus) [19]. While participants' RSA significantly decreased from baseline to walking into the labyrinth, RSA significantly increased to 4.0% above baseline after exiting the labyrinth (p<0.05). Participants' sAA significantly increased by 1.5% from baseline to the walk out of the labyrinth (p = 0.05, Cohen's d = 0.83, a large effect) [19]. The decrease in RSA and increase in sAA suggest that participants were cognitively and emotionally engaged (physiologically aroused) while labyrinth walking. After labyrinth walking, the increase in RSA to above its baseline level suggests that participants were physiologically relaxed after exiting the labyrinth. This finding contrasts with that of Sandor and Froman (2006) [24] and should be explored. One reason for the difference may be that participants in Sandor and Froman (2006)'s study walked a labyrinth in groups instead of solo [24]. Another reason may be that heart rate and respiratory rate were not measured long enough after labyrinth walking to reveal post-walk decreases. Future studies must compare the physiological effects of group and solo labyrinth walking. Moreover, the studies should measure the physiological outcomes for a longer duration after the participants finish walking. Measurements taken later than the immediate post-intervention measurement may reveal whether labyrinth walking elicits delayed physiological effects. Also yet to be determined are the potential physiological effects of multiple bouts of labyrinth walking.

In this review, the potential physiological effects of multiple bouts of labyrinth walking were discussed by only two articles. Boardman *et al*. (2017) assigned 26 employees of an orthopedic medical center into three groups for eight weeks: labyrinth walking (three times weekly), meditative neighborhood walking (three times weekly), or waitlist control [20]. Before and after the eight weeks, participants' salivary cortisol was measured. The negative slope of cortisol across the day was hypothesized to steepen (i.e. cortisol would decline faster across the day) because of labyrinth walking reducing physiological stress [20]. This hypothesis was not supported. At eight weeks, the slope of salivary cortisol had not significantly changed from baseline and did not differ among any of the three groups (p = 0.633) [20]. In a separate study, Zucker and Sharma (2012) evaluated the effects of a six-week labyrinth walking intervention on 14 incarcerated men[23]. The intervention was one session per week for six weeks. Each session required the men to listen to a live lecture, walk a labyrinth, and journal about their experience. The lectures covered labyrinths, self-esteem, positive thinking, inner peace, relaxation, and forgiveness. At baseline and after the sixth week, systolic and diastolic blood pressure were measured. It is unclear if blood pressure improved because missing data and a small sample size prevented a statistical analysis of the pre-post data[23]. Future studies should prioritize complete datasets and larger sample sizes. These qualities will enable statistical analyses and conclusions about how multiple bouts of labyrinth walking affect blood pressure and other measures of physiology. Collectively, the articles that discussed the physiological effects of single and multiple labyrinth walks are inconclusive and limited.

By comparison, the articles that discussed the psychological effects of labyrinth walking suggest a benefit and are greater in number. Four of the articles were written by groups of authors already mentioned. First, Sandor and Froman (2006) reported that one labyrinth walk increased positive affect (d = 0.22, small effect) and decreased negative affect (d = 0.56, moderate effect) [24]. Second, Zucker *et al*. (2016) reported that one labyrinth walk increased feelings of relaxation (p<0.001), peacefulness (p<0.001), and reflection (p = 0.003) and decreased feelings of anxiety (p = 0.001), stress (p = 0.009), and agitation (p = 0.008) [21]. Third, Boardman *et al*. (2017) reported that eight weeks of labyrinth walking did not significantly decrease perceived stress [20]. However, the labyrinth walking significantly decreased agitation, anxiety, and stress and significantly increased peaceful, quiet, and relaxed feelings [20]. Fourth, Zucker and Sharma (2012) measured quality of life but did not statistically analyze the data [23]. These four articles suggest that labyrinth walking may not affect incarcerated men's quality of life but may generate positive emotions in non-incarcerated adults.

In other non-incarcerated adults, labyrinth walking may generate negative emotions. In a study by Lizer *et al*. (2018), 30 participants from an integrative therapy institute, mostly spiritual and highly educated women aged 50-59 years, walked a labyrinth for 25 minutes and completed questionnaires about their experiences [18]. One-fifth to over four-fifths of the participants reported emotional distress during at least one phase of the labyrinth walk (while entering, exiting, or both). Besides the distress, participants experienced thoughts of their family, phases of life, and being in a safe place. A minority of participants experienced troubled thoughts (14%). Perception was altered too, with nearly one-fifth of the participants reporting they lost track of space and time and up to 86% reporting altered sensations, especially of feeling and hearing (e.g. feeling leg heaviness and hearing sounds other than the ambient noise) [18]. These findings show that labyrinth walking was associated with a wide range of emotional, cognitive, and sensory experiences among spiritual, highly educated, and middle-aged Brazilian women who sought integrative therapy. The findings highlight a gap in the knowledge about labyrinth walking: why do people's experiences of labyrinth walking vary from positive to negative?

This question may be partially answered by considering the previously mentioned study by Behman *et al*. (2018) [19]. This group collected youth and young adults' emotional experiences while labyrinth walking. The participants mostly reported that labyrinth walking increased their awareness, calmness, peacefulness, and relaxation and reduced their anxiety and stress [19]. These positive experiences may have been fostered by the labyrinth's environment. There was dim lighting, quiet music, and a welcoming research assistant present [19]. These features may have preconditioned the youth and young adults to have positive experiences. Another reason for the youth and young adults' more positive experiences than the Brazilian women's is that the latter were seeking psychotherapy. The Brazilian women may have had underlying emotional difficulties that preconditioned them to feel distressed while labyrinth walking [18]. Unlike the one-fifth to four-fifths of Brazilian women who felt distress while labyrinth walking [18], only one-fifth of the youth and young adults reported increased stress, mostly just upon entering the labyrinth [19]. Overall, the youth and young adults' positive qualitative responses align with their physiological data that showed decreased physiological arousal (RSA of the sample mean above baseline) after exiting the labyrinth [19]. In addition to emotional responses, some of the youth and young adults reported altered perceptions of sensations and time (e.g. labyrinth walking caused leg heaviness and gave them time to think about themselves and notice their surroundings) [19]. These responses are similar to the Brazilian women's responses [18] and support the hypothesis that labyrinth walking affects emotions, sensations, and thoughts among diverse populations.

Another population that may be positively affected by labyrinth walking is adults with mental illness who mandatorily reside in forensic mental health facilities. People from this population were recruited for Heard *et al*. (2015)'s qualitative study [22]. The study participants completed a Walking the Labyrinth program and qualitative interviews. The interviews revealed eight overarching themes [22]. While walking, participants felt (1) a sense of reflection and focus, (2) relaxation, and (3) a transcendent spiritual connectedness while labyrinth walking. After walking, participants felt (4) a sense of peace and (5) accomplishment or success. The program served as (6) a sense of escape and source of (7) stress reduction and (8) meaning making [22]. These themes suggest that, despite the participants' mental illness and confinement, labyrinth walking generated positive emotions and thoughts. However, important details of the Walking the Labyrinth program were not reported, such as the participants' instructions and the duration and number of sessions. These details are needed for the program to be replicated and evaluated in future qualitative, quantitative, and mixed-methods research studies.

Methodological Limitations

The present review has a few methodological limitations. The first limitation is that the review does not formally evaluate the included articles' risk of bias and quality. This decision was made to expedite the review. Readers must determine the trustworthiness and value of the articles in the review on their own. This limitation could not have been avoided because this review was conducted by one author. Formal evaluations require at least two authors to independently evaluate the risk of bias and quality. The second limitation is that the references of included articles were not searched to find more relevant articles. This limitation means relevant articles could have been missed, but the limitation does not negate the value of the Results and Discussion. This review is exploratory and seemingly the first of its kind, so the 18 included articles are sufficient to give the reader an overview of how labyrinth walking affects physiology and psychology. The third limitation involves the language, location, and publication biases. The review only contains peer-reviewed academic journal articles written in English and indexed in Google Scholar. Studies that were never published or indexed in Google Scholar could not be included in the review. Though this means relevant articles could have been missed, this risk is inherent to reviews of English-only articles and use one database. In the future, reviews should avoid this limitation by including articles written in more languages and indexed in more databases, such as Academic Search Premier and PubMed.

Conclusion

Despite its limitations, the present review meaningfully contributes to the literature about labyrinth walking. For the first time, the literature now has a qualitative narrative synthesis of the physiological and psychological effects of labyrinth walking. The main finding was that labyrinth walking has unclear physiological effects but mostly positive psychological effects. Diverse groups of people from several countries reported positive emotions, sensations, and thoughts during and after labyrinth walking. Notably, some participants from the research studies in this review enjoyed labyrinth walking enough to continue on their own for weeks to months after the studies ended. Further research is needed to clarify the physiological and psychological benefits of labyrinth walking and whether the activity benefits cardiovascular health. The two most important qualitative questions to answer are why people enjoy labyrinth walking and whether labyrinth walking motivates people to achieve higher levels of physical activity.

To clarify both the physiological and psychological effects of labyrinth walking, future studies should always have at least one control group and randomized group allocation. These characteristics will enable researchers to determine if labyrinth walking causes physiological or psychological changes. The characteristics will also minimize the risk of

baseline group differences confounding the relationships between labyrinth walking and outcomes of interest. An especially important baseline characteristic of participants that should be measured and balanced across groups is experience with meditation and mindfulness practices. People with experience may have different physiological and psychological responses to labyrinths than people without experience. Besides baseline group differences, participants' expectancy effects should be minimized. Researchers must use their best judgment when choosing the introductory material, instructions, lighting, and music for the labyrinth walk. These features and which labyrinth design are used may affect participants' responses. Thus, the features should be stated in study reports so that other researchers can interpret and replicate the studies. Last, most studies in this review recruited samples predominantly comprising females who completed one labyrinth walk. Future studies should recruit comparable numbers of males and females and should also investigate the effects of multiple labyrinth walks. These studies will explain whether the potential physiological and psychological effects of labyrinth walking depend on sex and the number of labyrinth walking sessions.

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