

It's about time to exercise: development of the Exercise Participation Explained in Relation to Time (EXPERT) model

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ABSTRACT

A perceived 'lack of time' is consistently the most commonly reported barrier to exercise. However, the term fails to capture the multifaceted nature of time-related factors. Recognising the need for a more comprehensive analysis of 'lack of time' as a barrier to exercise, the aim of this study was to develop the exercise participation explained in relation to time (EXPERT) model. The model was developed through a sequential process including (1) an umbrella literature review of time as a barrier, determinant, and correlate of physical activity; (2) a targeted review of existing temporal models; (3) drafting the model and refining it via discussions between eight authors; (4) a three-round Delphi process with eight panel members; and (5) consultations with seven experts and potential end-users. The final EXPERT model includes 31 factors within four categories: (1) temporal needs and preferences for exercise (ie, when and how long does an individual need/want to exercise), (2) temporal autonomy for exercise (ie, autonomy in scheduling free time for exercise), (3) temporal conditions for exercise (ie, available time for exercise) and (4) temporal dimensions of exercise (ie, use of time for exercise). Definitions, examples and possible survey questions are presented for each factor. The EXPERT model provides a comprehensive framework for understanding the multi-dimensional nature of 'time' as it relates to exercise participation. It moves beyond the simplistic notion of 'lack of time' and delves into the complexity of time allocation in the context of exercise. Empirical and cross-cultural validations of the model are warranted.

INTRODUCTION

Physical activity is associated with a plethora of health, psychological, social, economic and environmental benefits.¹⁻³ Despite this, insufficient physical activity remains pervasive in the population.⁴ This article focuses specifically on exercise; a specific type of physical activity usually defined as planned, structured and repetitive bodily movement performed during leisure time with the primary purpose of improving or maintaining physical fitness, physical performance and/or physical, mental and social health and well-being.⁵ Although data suggest time spent in exercise is particularly beneficial for health,⁶ most people do not exercise regularly.⁷

WHAT IS ALREADY KNOWN?

⇒ Globally, a perceived 'lack of time' is the most commonly reported barrier to exercise, but it does not necessarily correlate with actual time commitments.

WHAT ARE THE NEW FINDINGS?

- ⇒ Our overreview of reviews found that the lack of time and competing time demands/preferences are the most commonly cited temporal factors related to physical activity and exercise.
- ⇒ Our review found that previous theoretical/conceptual models depicting the multi-dimensionality of time allocation factors refer to leisure time, working time, temporal flexibility, temporal demands of work, temporal profile of a situation, time scarcity and time wealth.
- ⇒ According to the newly developed exercise participation explained in relation to time model, a comprehensive analysis of 'lack of time' to exercise should encompass (1) needs and preferences in relation to when and how long to exercise, (2) autonomy in scheduling free time for exercise, (3) available time for exercise and (4) use of time for exercise.

Studies consistently identify a perceived lack of time as a key barrier to exercise among adults.⁸⁻¹⁰ In survey-based studies, approximately 50% of adults report a perceived lack of time as their barrier to exercise.¹¹⁻¹³ Several qualitative studies lend further testament to the issue of perceived time scarcity for exercise.^{11 14 15} However, data suggest time commitments do not predict perceived a lack of time for exercise.¹⁶ Further underscoring the inadequacy of the term 'lack of time' as a barrier to exercise, Rebar *et al*¹⁷ found that whether adults find time to be physically active is not dependent on whether they perceived to lack time for exercise or not. The results led the authors to conclude that the barrier of not having enough time to be active might 'be a fallacy'.¹⁷ Moreover, Biddle¹⁸ highlighted the need for a more comprehensive analysis of the barrier of a 'lack of time' for PA noting the insufficiency of the term to capture the multifaceted nature of time.

A more comprehensive exploration of time, as it pertains to physical activity (PA) and specifically



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exercise, is required. Broadly speaking, this exploration can encompass two perspectives. First, we can focus on temporal *determinants* of exercise. Typically, research on the temporal determinants focus simply on a ‘lack of time’ for exercise. This reductionist perspective may hamper the study and promotion of exercise. Research examining the ‘lack of time’ as a barrier to exercise may omit other influential time-related factors, rendering our understanding of time’s relationship to exercise as incomplete. For example, the timing of a person’s ‘free time’ for exercise may be influential, as it may or may not fall within the typical business hours of exercise facilities. Also, perceived control over one’s time is gaining empirical support as important determinants of exercise.¹⁹ Interventions that seek to address the ‘lack of time’ for exercise may be suboptimal or ineffective unless other important time-related determinants are also addressed. Second, temporal *characteristics* of exercise require a more comprehensive examination. To fully comprehend the ‘lack of time’ as a barrier, we must consider the temporal characteristics of exercise. Typically, from a temporal perspective, exercise is defined in terms of the frequency and duration of exercise bouts.²⁰ However, a more nuanced perspective is needed. Recently, for example, the potential importance of *timing* of exercise and *consistency* of exercise timing have gained attention.^{21–23} It is evident that a more multi-dimensional perspective of time as a determinant and characteristic of exercise is needed.

Time-related factors have been a subject of extensive discussion and theorisation among philosophers and scientists.²⁴ The abstract and philosophical contemplations of ‘time’ often present it as an essential yet enigmatic aspect of the universe.²⁴ It is open to diverse interpretations across philosophical and scientific domains, reflecting its complex and multifaceted nature. From a more pragmatic perspective, ‘time’ is discussed and examined as a multi-dimensional concept, in terms of how it relates to facets and behaviours of life such as work, leisure, family-life and education.^{25–28} Scholars have proposed the concept of ‘time’ to be composed of a multitude of dimensions, which may be co-dependent, including duration, timing of events, autonomy over time and synchronisation of time with others.^{28–29} Others have considered temporal factors such as the subjective feeling of time pressure and fragmentation of leisure time²⁷ and the value and importance placed on leisure time and one’s appraisal of effective use of time.³⁰ To date, however, despite the lack of time being the most commonly reported barrier to exercise, most other dimensions of ‘time’ as they pertain to exercise have received little or no attention.

Exercise participation is frequently described in terms of what exercise people engage in (ie, types of exercise), who they exercise with (ie, exercise partners), why they exercise (ie, exercise motivation) and where they exercise (ie, exercise settings). However, despite the consistent emergence of ‘time’ as a barrier to exercise, the *when* of exercise is under-studied and most often limited to quantifying the frequency (ie, how many times) and duration of exercise, as reflected in the frequency, intensity, time and type principles, commonly used for exercise prescription purposes.³¹ Therefore, to guide future research and prompt a more comprehensive and systematic consideration of the temporality of exercise, the aim of this article was to develop the *exercise participation explained in relation to time* (EXPERT) model, presenting the time-related factors relevant to exercise.

METHODS

Based on conceptual framework development protocols used in previous studies,^{32–34} the following series of sequential steps

were employed to develop the EXPERT model: (1) a systematic review of reviews was conducted to synthesise how time-related factors are defined as correlates, determinants, barriers and facilitators of PA and exercise; (2) a targeted literature review was conducted to identify existing conceptual models presenting time allocation as a multi-dimensional construct; (3) the EXPERT model was drafted by the lead author and refined based on open discussions between eight members of the authorship team; (4) the model was further revised by the eight members of the authorship team via a three-round Delphi process; and (5) the model underwent final refinement based on a consultation process with seven authors who are experts on PA/exercise and/or sociology of time and potential end-users of the model.

Step 1: systematic review of reviews of temporal factors related to PA and exercise

A review of reviews was conducted to map and synthesise the existing evidence on temporal factors as correlates, determinants, barriers and facilitators of PA and exercise. Systematic reviews and meta-analyses that aimed to synthesise literature related to correlates, determinants, barriers and facilitators to PA were identified from three databases: PubMed, SPORTDiscus and Web of Science Core Collection. The search syntax was as follows: (“Systematic review” OR “Meta-analysis” OR “Literature review” OR “Narrative review”) AND (“Correlates” OR “Determinants” OR “Barriers” OR “Factors”) AND (“Physical activity” OR “Exercise”). The search was conducted on 31 January 2023. Articles were included in the review if they were (a) on correlates, determinants, barriers and/or facilitators of PA or exercise among adults and (b) published between January 2013 and January 2023. Articles were excluded if they (a) specifically applied a framework that would exclude time allocation factors (eg, a focus on biological or physical environment), (b) did not include studies with adults and (c) focused on specific populations with a clinical diagnosis/condition (eg, exercise for back pain, dementia and cancer). Reference list searches (ie, backward citation tracking) were also conducted. See figure 1 for an overview of study selection according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 statement. Data extraction and synthesis were conducted in two stages. First, definitions of temporal factors as determinants or correlates of PA and exercise were identified and collated from reviews of quantitative and mixed-methods articles. Second, statements that mentioned temporal factors as a barrier or facilitator to PA and exercise were identified and collated from reviews of qualitative or mixed-methods studies. Literature searches were conducted by SH. Data extraction was completed independently by SH and JC.

Step 2: targeted review of temporal models

To identify how temporal factors have been conceptualised as a multi-dimensional construct, a targeted review of existing conceptual frameworks and models was conducted. This step is suggested for ‘idea generation’ and to inform decisions about the universe of factors that can be studied in relation to temporality and exercise.³² Examining models from fields other than PA and exercise prompted and enabled the consideration of other disciplines and the application of paradigms from one discipline to another.³² Bibliographic databases (PubMed, SPORTDiscus and Web of Science) and Google Scholar were searched for research articles and grey literature, respectively. Search terms included variations of ‘models of time’, including ‘framework’ and

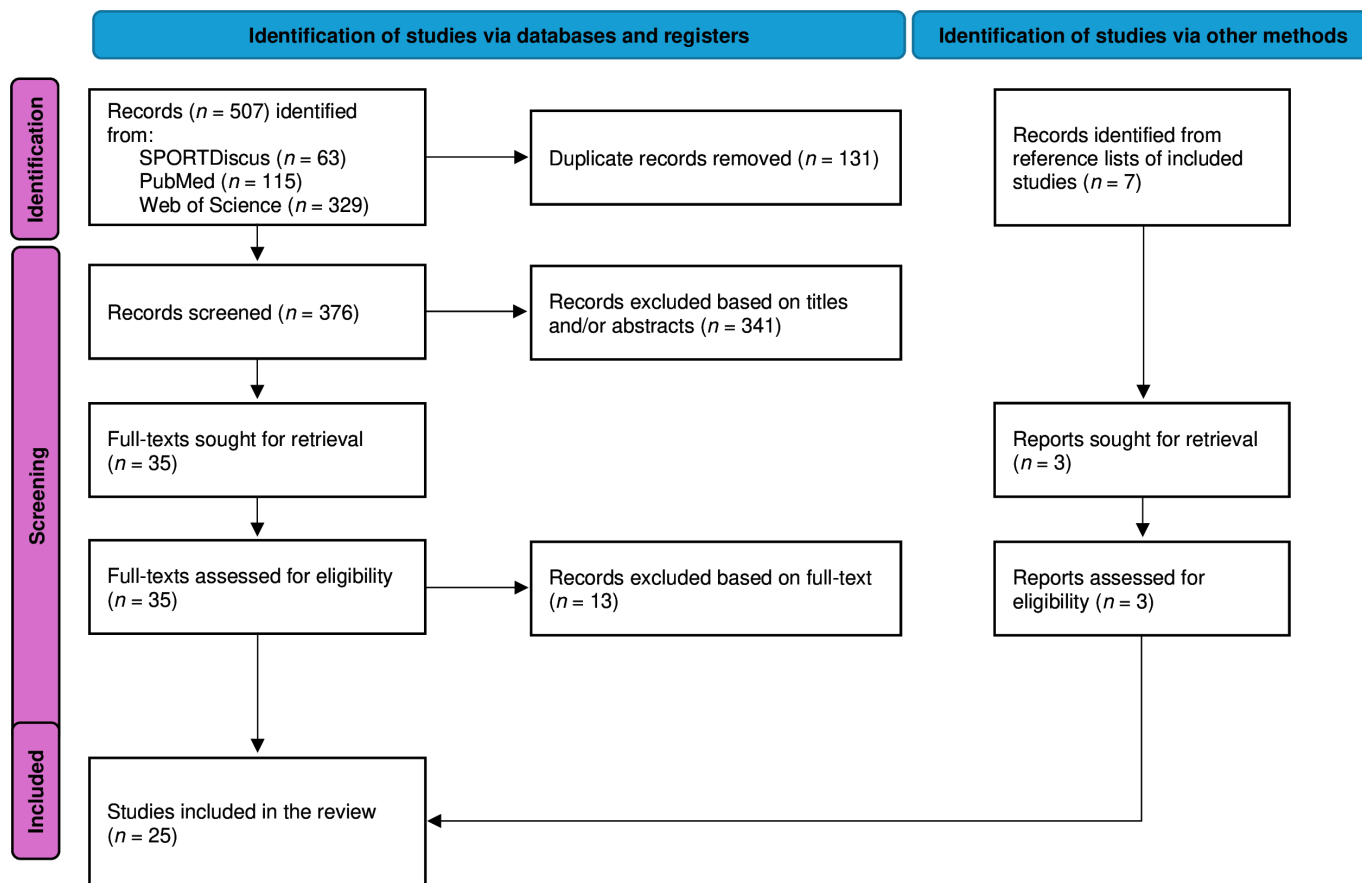


Figure 1 Flow chart of the literature search and study selection process.

'dimensions of time'. The search was conducted in January 2023. To increase the likelihood of identifying models and frameworks of time from a multitude of disciplines, broad inclusion criteria were applied. Articles were included for review if they presented a 'model' or 'framework' related to the dimensions of time. No date of publication restrictions were applied. Reference lists of articles that presented models/frameworks related to time were also searched. The dimensions of time were collated, and dimensions were considered for their relevance for exercise. Literature searches and data extraction were conducted by SH. Data extraction was completed independently by SH and JC.

Step 3: drafting and revising the EXPERT model based on open discussions

Based on literature reviews, the initial draft of the conceptual model was developed by the lead author. Eight authors (CW, DD, FP, IG, SB, SH, TO and ZP) then had open discussions to refine the model. The eight authorship team members were purposefully selected due to their extensive experience in PA epidemiology, time-use epidemiology, exercise psychology, sociology of time and model development. All Delphi process participants indicated an intention to use the model in their future research, and all, except one, indicated an intention to use it in their practice. The aim of this stage was to refine the model structure and its components. This stage allowed for the first draft of the model that was informed by the literature review, to be expanded based on additional theoretical, key stakeholder-based and evidence-based rationales.³² The team discussed the model via three rounds of email discussions and three team meetings held via teleconference.

Step 4: Delphi process

The Delphi method, a systematic means of reaching consensus between experts via interactive communication,³⁵ has been used extensively in PA research.^{33 36 37} The eight authors from step 3 (CW, DD, FP, IG, SB, SH, TO and ZP) engaged in a Delphi process to conclude the discussions from step 3 and further refine the EXPERT model. The process involved three series of electronic anonymous surveys administered to the expert panel and was facilitated by an independent researcher from outside the research team. The first round involved presentation of the draft of the EXPERT model via a supplementary document and a series of questions on the respondents' agreement or disagreement with the model title; the inclusion, proposed names and definitions of the model categories; the proposed relationship between model categories; and the inclusion, proposed names and proposed definitions of the factors within each category. Respondents answered 'Yes' or 'No' to each question, with a follow-up open-ended question allowing for suggestions to be provided if respondents disagreed with an element of the model. Data from each survey were analysed, and the level of agreement with each element of the model was calculated. When less than 75%³⁸ of the expert panel agreed on an element of the model, actions were taken to edit the aspect of the model. Subsequent rounds of the process then involved the updated model presented to the EXPERT panel who were once again queried on their level of agreement on the updated aspects of the model. As part of the second and third round of the Delphi process, the EXPERT panel received a full report on data from the prior round of the Delphi process. This was repeated until consensus was reached on all elements of the model. During each round,

respondents also had a chance to suggest minor edits to the wording of category and factor definitions.

Step 5: EXPERT consultation

The final model development stage involved consultations with a panel of seven PA and exercise researchers and professionals (AB, AG, KK, MH, SBT, SV and UL). Their role was to provide feedback on the elements and definitions within the proposed EXPERT model. The consultant author group was purposefully selected due to their extensive expertise in PA epidemiology, time-use epidemiology, PA patterns, exercise psychology, time-use research/sociology, PA policy and PA promotion. To ensure the usefulness of the EXPERT model for scientists and practitioners, in addition to the consultant authors' research expertise, they were also selected because of their wealth of experience in promoting PA via local, national and international organisations, public health consultancy and advocacy and health policy. All expert consultants, except one, indicated an intention to use the model in their future research and all intended to use it in their practice. Members of the consultant author group were invited via email to provide input on the penultimate draft of the model via email using tracked changes and comments in MS Word or, if preferred, to discuss their feedback via teleconference with the first author (all consultants opted for feedback via email). Eight consultants were invited, of which seven agreed to participate. Proposed changes to the model based on consultant feedback were discussed between all members of the team and culminated in the refinement and finalisation of the model.

Equity, diversity and inclusion statement

Our authorship team includes both men (n=9) and women (n=5) with early, mid and late career researchers. The Delphi process involved eight participants (three females, $m^{age}=54$). The consultation process involved seven participants (three females, $m^{age}=52$). The team includes members from eight countries spanning three continents. The review of reviews that informed the EXPERT model design included systematic reviews focused on populations diverse in terms of age, gender, race, ethnicity and socioeconomic status. We hope the EXPERT model may be a valuable tool to enable a more nuanced examination of how 'time-wealth for exercise' determines disparities in exercise participation between disadvantaged groups. Acknowledging that the model's development may be constrained by the cultural and social representativeness of the development team (eg, the team did not include members who identify as having a disability and all reside in middle-high-income countries) and the literature underpinning the model, we also encourage cross-cultural validations of the EXPERT model to verify its generalisability.

RESULTS

Systematic review of reviews of temporal factors and PA

A total of 507 articles were identified from the initial search (115 in PubMed, 63 in SPORTDiscus and 329 in Web of Science), and after the removal of 131 duplicates, 376 articles remained for title and abstract screening. Title and abstract screening resulted in the selection of 35 articles for full-text review. Full-text review identified 22 articles that meet the inclusion criteria. Further three articles were identified via backward citation tracking. Therefore, the umbrella systematic review identified 25 reviews on determinants, correlates, barriers and facilitators of PA and exercise, including reviews of quantitative studies (n=10), qualitative studies (n=4) and mixed-methods studies (n=11). Time allocation factors were cited as correlates,

determinants, barriers or facilitators of PA in 72% of articles (table 1). There were nine inconsistencies between reviewers, which were resolved via discussion and revisiting of the articles in question. Most common references to time allocation factors included terms related to the actual lack of time (eg, time limits, time constraints), competing time demands/preferences (eg, concurrent behaviours, work demands or screen time) and perceived lack of time (eg, feeling too busy, perceived lack of control of time).

Targeted review of temporal models

Ten conceptual frameworks presenting 'time' as a multi-dimensional construct were identified and reviewed. Table 2 provides an overview of the models and their underlying dimensions. Models were published between 1985 and 2022, and they significantly overlapped. Three models represented 'time wealth'^{27 28 39} and three models defined 'working time'.^{26 40 41} Other models represented constructs such as 'temporal flexibility',⁴² 'temporal profile of a situation'²⁹ and dimensions of the leisure time perspective.³⁰ The majority of models included a dimension related to duration of activities (eg, working time duration, amount of time of an activity, number of hours worked, reasonable amount of time for leisure). Other common dimensions of time allocation related to one's perception of their control over their time (eg, sufficiently self-determined time, working time autonomy), perceptions of having enough time or feeling rushed, other people's perceptions and value of time and the sequence or timing of events (table 2).

Drafting and revising the EXPERT model based on open discussions

The first draft of the EXPERT model, developed by the lead author, consisted of nine factors (online supplemental figure S1). The subsequent open discussions among eight members of the author team resulted in refinement of the model reflected in six drafts of the model (online supplemental figure S1). One refinement of note was the decision to focus on broadly defined exercise, as opposed to all physical activities. This decision was motivated by the fact that exercise, as a typically voluntary, planned and structured activity, is quite distinct from other types of PA. For example, occupational PA is often obligatory and tied to job tasks, and individuals often cannot adequately control its timing and duration. Draft six included four categories of factors, with a total of 31 factors.

Delphi process

Round 1 of the Delphi process resulted in three disagreements (from questions on 34 model components). Four of eight panel members disagreed with the proposed relationship between the categories within the EXPERT model and five made suggestions for this component. Generally, disagreements were due to the initial suggestion that the relationships between model factors are typically unidirectional. Three of eight panel members disagreed with the name and/or definition of the factor: 'Duration of free-time (total)' and its definition and the name and/or definition of the factor: 'Duration of exercise (total)'. Several suggestions were provided to improve the titles and definitions.

In response to the Delphi round-one feedback, round two involved two versions of the model being proposed: one proposing a longitudinal model and one proposing a cross-sectional model reflecting the complex relationship between factors. Moreover, the titles and definitions were updated for the factors 'Duration of free-time (total)' and 'Duration of

Table 1 Mentions of time as a determinant, correlate, barrier or facilitator of physical activity in the literature: findings of a systematic review of reviews

	Review	Study designs reviewed	'time' referenced in the review?	Mentions of time as a determinants, correlate, barrier or facilitator of PA
1	Amireault <i>et al</i> (2013) ⁵⁷	Quan	No	NA
2	Choi <i>et al</i> (2017)	Quan	Yes	"Overtime work hours", "fixed day time work", "full-time employment", "lack of time"
3	Craike <i>et al</i> (2019) ⁵⁸	Quan	No	NA
4	Evans <i>et al</i> (2022) ⁵⁹	Quan	Yes	"lack of time", "time constraints", "time devoted to studies"
5	Liangruenrom <i>et al</i> (2019) ⁶⁰	Quan	Yes	"more spare time", "sedentary time", "more time spent with family"
6	Lounassalo <i>et al</i> (2019) ⁶¹	Quan	Yes	"having low television viewing time"
7	Pan <i>et al</i> (2022) ⁶²	Quan	Yes	"lack of time"
8	Picorelli <i>et al</i> (2014) ⁶³	Quan	No	NA
9	Tovar <i>et al</i> (2018) ⁶⁴	Quan	Yes	"perceived behavioural control over time"
10	Hilland <i>et al</i> (2020) ⁶⁵	Quan	No	NA
11	El Masri <i>et al</i> (2021)	Qual	Yes	"competing commitments and time", "little time to engage in PA"
12	Gidgup <i>et al</i> (2022) ⁶⁶	Qual	Yes	"lack of time"
13	Ige-Elegbede <i>et al</i> (2019)	Qual	Yes	"lack of time"
14	Horne and Tierney (2012) ⁶⁷	Qual	Yes	"lack of time", "taking time to look after oneself (eg, exercising)"
15	Garcia <i>et al</i> (2022)	Mixed	Yes	"lack of time", "presence of concurrent behaviours", "time spent with friends"
16	Akande <i>et al</i> (2015) ⁶⁸	Mixed	No	NA
17	Condello <i>et al</i> (2017) ⁶⁹	Mixed	Yes	"screentime", "sedentary time", "lack of time", "time constraints"
18	Ferreira Silva <i>et al</i> (2022)	Mixed	Yes	"lack of time", "internet use, screen time and TV viewing", "time limitations"
19	O'Donoghue <i>et al</i> (2018) ⁷⁰	Mixed	Yes	"lack of time"
20	Brug <i>et al</i> (2017) ⁷¹	Mixed	No	NA
21	Spiteri <i>et al</i> (2019) ⁷²	Mixed	Yes	"lack of time", "PA was intentionally 'me time'" "People cannot keep it up. They won't have time, are looking for food, or a job and pay check" "Not enough time due to other obligations, mostly work and family" "Lacking time management skills" "There are people out there at this time of year, at 5:30 or 6:00 (a.m.), as soon as it's light. They will say, 'Hey, you're late!' Everybody knows each other"
22	Yarmohammadi <i>et al</i> (2019) ⁷³	Mixed	Yes	"Time limits", "having enough time", "having less time to spend with friends and family"
23	Yiga <i>et al</i> (2020)	Mixed	Yes	"Lack of time" "Long working hours and need to prioritise social obligations (family needs) were reported to be a major basis for insufficient time" "women oversee domestic affairs of the home... this coupled with the improving female labour market opportunities, and longer commuting hours. greatly diminishes available time for structural-related PA" "individual occupational related time constraints" (eg, unpredictable hours at work, lack of rest time, long working hours) "Time spent on passive forms of recreation (eg, television and social media)"

Continued

Table 1 Continued

	Review	Study designs reviewed	'time' referenced in the review?	Mentions of time as a determinants, correlate, barrier or facilitator of PA
24	Zou <i>et al</i> (2021) ⁷⁴	Mixed	Yes	"Lack of time" "lack of rest time" "A lack of time was mainly due to household responsibilities and work obligations" "occupational related time constraints were related to unstable employment, unfamiliar working conditions, unpredictable hours at work, lack of rest time, frequent changes of workplaces, difficulty in finding new work, long working hours, and/or increased job demands" "a lack of time due to occupational-related duties left them feeling too busy, tired or stressed"
25	Farrance <i>et al</i> (2016) ⁷⁵	Mixed	No	NA

.PA, physical activity.

exercise (total)'. Round two resulted in one disagreement (from questions on three model components). Three of eight panel members disagreed with the proposed longitudinal theoretical model suggesting a cross-sectional model was sufficient and would reflect the likely complex relationship between model factors. In response to round two feedback, the longitudinal theoretical model was removed. A single model was presented in round three acknowledging that the relationships between model factors are complex and likely bidirectional. The model visualisation was also improved to make it simpler and more visually appealing. The improved model figure just presented the model categories, while descriptions of the factors within each category and their examples were presented in a table. Round three resulted in 100% consensus.

Consultation with potential end-users

The rich exchange of feedback on the sixth and penultimate draft of the model led to the final refinement of the EXPERT model, enhancing its robustness, applicability and relevance for researchers and practitioners. No major changes to the model were proposed in the consultation process. However, important edits were made to improve clarity of model factor definitions. Several consultant authors (n=3) commented on a potential lack of distinction between category 2 (temporal autonomy for exercise) and category 3 (temporal conditions for exercise). The descriptors of the categories were refined to ensure clarity around the focus of category 2 on autonomy for *scheduling* free-time for exercise. The consultation process has resulted in the final (seventh) version of the EXPERT model.

The final model

The final EXPERT model includes 31 temporal factors, presented within four categories (figure 2 and table 3). The categories and their factors are as follows:

1. **Temporal preferences and needs for exercise.** The factors within this category define an individual's preferences in relation to time for exercise. The factors within this category include *preferences and needs* regarding total exercise duration, exercise frequency, exercise duration, exercise timing, exercise sequence, regularity/routine of exercise, synchronisation of exercise with internal rhythms (eg, circadian rhythms, menstrual cycle) and external rhythms (eg, work/school schedule, family schedules, timing of exercise

programmes) and polychronic time-use for exercise (ie, multi-tasking, simultaneously engaging in multiple activities, including exercise).

Example Olivia wants to exercise for 150 minutes a week spread across 5 days. During weekends, she wants to exercise for at least an hour. Olivia prefers to exercise in the evenings and prefers consistency in her exercise routine. She does not need to synchronise her exercise routine with that of her partner.

2. **Temporal autonomy for exercise.** The factors within this category define an individual's *autonomy in scheduling* their activities to enable free time to exercise. It reflects the degree to which an individual has personal choice and control over when and how much free time they have to exercise. Free time is simply the time in which an individual's activities are not dictated by the 'necessities of life' such as paid and unpaid labour (eg, household duties, child minding) and personal care (eg, eating, sleeping and bathing).⁴³ This category of factors provides an important distinction between people who may have the same amount of free time but have differing degrees of control over when the free time occurs. The factors within this category include an individual's *autonomy* over their total amount of free time, frequency of free time periods, duration of free time periods, timing of free time periods, fragmentation of free time periods, routine/regularity of free time periods and polychronic use of free time periods.

Example. Due to employment and parenting duties, Olivia feels she has no control over scheduling when or for how long she has free time to exercise on week days. On Sundays, she has autonomy over scheduling the timing and duration of her free time.

3. **Temporal conditions for exercise.** The factors within this category define an individual's *available time* for exercise. This category of factors represents the time a person has when they may choose to exercise, that is, the available time to exercise after they have used (or decided not to use) their autonomy to schedule free time for exercise. The factors within this category include an individual's total amount of free time, frequency of free time periods, duration of free time periods, timing of free time periods, fragmentation of free time periods, routine/regularity of free time periods and polychronic use of free time periods. For example, the total amount of free time available for exercise can be calculated

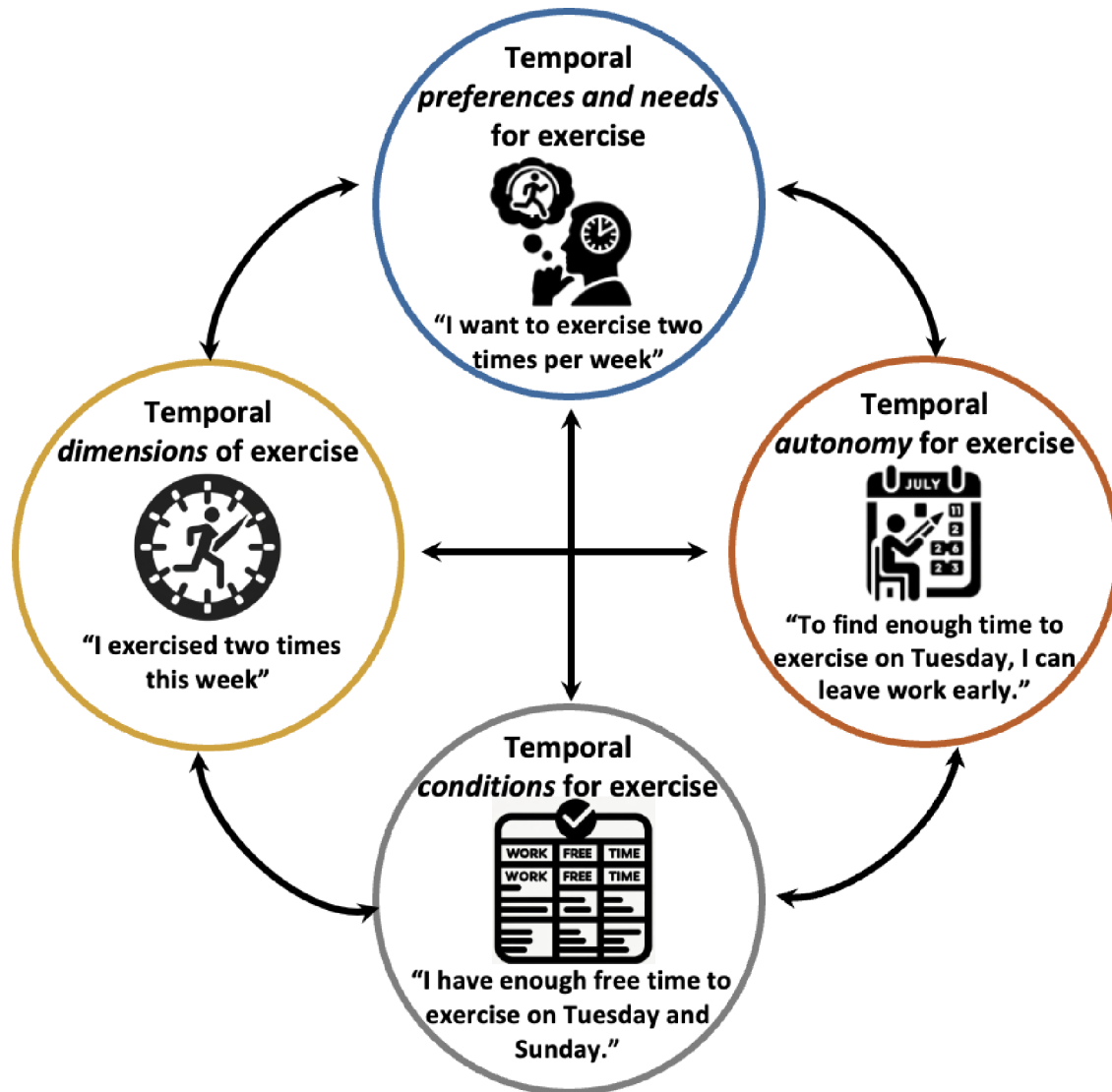
Table 2 Theoretical/conceptual models depicting the multi-dimensionality of time allocation factors: findings of a targeted review

Author (year)	Dimensions of...	Dimensions
Geiger <i>et al</i> (2021) ³⁹	Time wealth	<ul style="list-style-type: none"> ▶ A reasonable amount of discretionary time (sufficient time) that facilitates adequate time per activity (unhurried pace) at a sufficiently stable horizon of expectation (plannability) under sufficiently self-determined conditions (sovereignty) where they can satisfactorily coordinate different temporal requirements (synchronisation).
Tsaur and Yen (2022) ³⁰	The dimensions of the leisure time perspective	<ul style="list-style-type: none"> ▶ Time-use meaning: the degree of value and importance of leisure time use. ▶ Time structure: individual's appraisal of their effective use of time. ▶ Pace preference fit: the degree to which leisure participants engage in leisure activities at their preferred pace. ▶ Social orientation: individuals' willingness to share their leisure time with others. ▶ Polychronic orientation: an individual's level of preference for engaging in multiple leisure activities concurrently within a period of leisure time.
Karhula <i>et al</i> (2020) ⁴⁰	Working time	<ul style="list-style-type: none"> ▶ Working time duration. ▶ Timing of work. ▶ Working time autonomy. ▶ Work tempo.
Zerubavel (1985) ²⁹	Temporal profile of a situation	<ul style="list-style-type: none"> ▶ Sequential structure tells us in what order situations or events take place. ▶ Duration tells how long they last. ▶ Temporal location tells when these events take place. ▶ The rate of recurrence tells us how often they take place.
Reisch (2001) ²⁸	Time wealth	<ul style="list-style-type: none"> ▶ Chronometric dimension, which is the amount of time (or duration). ▶ The chronologic dimension or the timing: having time at the right time of the day, the week or the season. ▶ Having personal autonomy over time. ▶ Synchronisation, having free time together with family and friends.
Mullens and Glorieux (2020) ²⁷	Time wealth	<p>To Reisch's (2001) and Zerubavel's (1981) dimensions of time wealth (above), they added:</p> <ul style="list-style-type: none"> ▶ The subjective feeling of time pressure. ▶ Fragmentation of leisure as one of the measures for the quality of leisure time.
Anttila <i>et al</i> (2015) ⁴²	Temporal flexibility	<ul style="list-style-type: none"> ▶ Number of hours worked. ▶ When the hours are worked. ▶ Work-time intensity. ▶ The degree of working-time autonomy.
Fagan (2001) ²⁶	Working time	<ul style="list-style-type: none"> ▶ Numbers of hours worked. ▶ When they are worked. ▶ The degree of autonomy one has over their working hours.
Fine (1996: 55)	Temporal demands of work	<ul style="list-style-type: none"> ▶ Periodicity refers to the rhythm of the activity. ▶ Tempo, to its rate or speed. ▶ Timing to the synchronisation or mutual adaptation of activities. ▶ Duration, to the length of an activity. ▶ Sequence to the ordering of events.
Venn and Strazdins (2017) ⁷⁶	Time scarcity	<ul style="list-style-type: none"> ▶ 'Time poor' was defined as committed time (comprising paid work, commuting, child care, adult care, errands, housework, outdoor work and volunteer work) greater than 70 hours per week. ▶ 'Rushing' was defined as always or often feeling rushed or pressed for time.

as the overall time in a given period (eg, 24 hours in a day) minus the time spent on the perceived 'necessities of life'.⁴³

Example. Olivia has 30 min of free time for exercise on her week day mornings and 1 hour on her week day evenings after her children go to bed. On Saturday, Olivia has no free time to exercise. On Sundays, Olivia has free time to exercise at any time she prefers.

4. **Temporal dimensions of exercise.** The factors within this category are related to an individual's *use of time* for exercise. The factors within this category include an individual's total duration of exercise, exercise frequency, duration of an exercise session, timing of exercise, sequencing of exercise, routine/regularity of exercise, synchronisation of exercise with internal and external rhythms and collateral time cost of exercise.



Model assumptions:

- Each of these categories can be viewed as perceived (subjective) or actual (objective).
- Each of these categories can be studied within a given timeframe (e.g., day, week, month)
- All components of the EXPERT model, and the relationships between them, are influenced by factors from different levels of the social ecological model (for example, our temporal preferences for exercise may be shaped by personal values and beliefs about exercise, social and cultural norms about time use, socioeconomic status, employment status, etc.). Defining these variables is beyond the scope of this model

Figure 2 The exercise participation explained in relation to time model categories.

Example. Olivia exercises on three evenings a week for 30 min starting at 8pm, after her children are asleep. On Sundays, she exercises for 1 hour; sometimes in the morning and sometimes in the evenings. Her exercise routine is regular during the week but irregular (eg, starts at different times) during weekends.

The relationships between model factors are complex and likely bidirectional, which is acknowledged by potential relationships between all categories of factors in two and by the notion

that specific relationships between factors need to be illuminated in future research. All components of the EXPERT model, and the relationships between them, are influenced by factors from different levels of Bronfenbrenner's Ecological Systems Theory.⁴⁴ Temporal aspects of exercise are influenced and constrained by our micro-system (eg, school and work schedules, type of exercise engaged in), mesosystem (eg, workplace culture and family life), exosystem (eg, government policies, community resources

Table 3 The exercise participation explained in relation to time model categories and factors, with examples and possible survey questions

Category	Factor	Definition	Examples	Example survey question
Temporal preferences and needs for exercise	Preferences/needs regarding total exercise duration	How much time, in total, a person prefers/needs to exercise for?	A person may prefer to exercise for 150 minutes a week.	In total, how much time would you like to spend exercising in a week? (mins/week).
	Preferences/needs regarding exercise bout frequency	How often a person prefers/needs to exercise?	A person may prefer to exercise 5 days a week.	On how many days a week would you like to exercise? (0–7).
	Preferences/needs regarding exercise bout duration	How much uninterrupted time a person prefers/needs for a single bout of exercise?	A person may prefer at least 30 min to exercise.	What is the minimum uninterrupted period of time you require to complete the following exercise: jogging? (mins)
	Preferences/needs regarding exercise bout timing	When does a person prefers/needs to exercise?	A person may prefer to exercise in the evening.	When do you prefer to exercise? (AM or PM)
	Preferences/needs regarding exercise sequence	When does a person prefers/needs to exercise in relation to other activities?	A person may prefer to exercise before dinner.	In relation to the following activities, when do you prefer to exercise: work (before, after, doesn't matter)
	Preferences/needs regarding exercise regularity/routine	A person's preference/needs for consistency in the timing of their exercise.	A person may prefer to exercise at a fixed time each week (eg, a Saturday gym class).	To what degree do you prefer to participate in exercise at the same time/day each week? (not at all—a great degree)
	Preferences/needs regarding exercise synchronisation (with internal and external rhythms)	A person's preference/needs for their exercise to be in alignment with internal temporal rhythms (eg, circadian rhythm, menstrual cycle) or external temporal rhythms (social, institutions, cultural, environmental).	A person may prefer to exercise at the same time as their partner.	Do you prefer to exercise at the same time as your partner? (Yes, No)
	Preferences/needs regarding polychronic time-use for exercise	A person's preference/needs to exercise while simultaneously engaging in other activities.	A person may prefer to engage in exercise while watching TV.	To what degree do you prefer to exercise while doing other activities (eg, working, watching TV)? (Not at all—a great deal)
	Autonomy over the total amount of free time	A person's control over the total duration of free time they have.	A person can schedule their time so as they can have 2 hours of free time each day.	To what degree can you control the amount of free time you have in your day? (Not at all—a great deal)
	Autonomy over frequency of free time periods	A person's control over how often they have free time.	A person can schedule their time so as they can have free time each day.	To what degree can you control how many periods of free time you have in your day? (not at all—a great deal)
Autonomy over duration of free time periods	A person's control over how long their free time periods last.	A person can schedule their time so as they can have 2 hours of uninterrupted free time periods each day.	To what degree can you control the duration of your uninterrupted free time periods in your day? (not at all—a great deal)	
Autonomy over timing of free time periods	A person's control over when their periods of free time for exercise occur.	A person can schedule their time so as they can have free time in the evening.	To what degree can you control the timing of when your free time occurs in your day? (not at all—a great deal)	
Autonomy over fragmentation of free time periods	A person's control over having uninterrupted free time for exercise.	A person can schedule their time so as they can have an uninterrupted hour of free time each day.	To what degree can you control how your free time for exercise is interrupted by obligatory activities?	
Autonomy over routine/regularity of free time periods	A person's control over the consistency of their periods of free time available for exercise.	A person can schedule their free time so as they can have time for exercise at the same times and on the same days each week.	To what degree can you control your free time so you can exercise at the same time each week? (not at all—a great deal)	
Autonomy over polychronic use of free time periods	A person's control over using their free time to participate in multiple activities simultaneously.	A person can schedule their free time so as they can exercise while completing some work activities (eg, virtual meetings).	To what degree can you complete exercise while you complete the following activities: mind your children? (not at all—a great deal)	

Continued



Temporal autonomy for exercise



Table 3 Continued

Category	Factor	Definition	Examples	Example survey question
Temporal conditions for exercise	Duration of free time for exercise	The total duration of free time a person has available for exercise in a given period (eg, day, week, month).	A person has 2 hours of free time in a day.	How much free time do you have in your day?
	Frequency of free time for exercise	How often a person has free time available for exercise?	A person has 2 periods of free time in a day.	How many periods of free time do you have in your day?
	Timing of free time for exercise in a day	Time of the day when a person has free time available for exercise in a day.	A person has free time in the late evenings only.	When does your free time typically occur? (morning/afternoon/evening)
	Sequencing of free time for exercise	The timing of free time available for exercise in relation to other activities.	A person has free time only before going to work.	When does your free time typically occur, in relation to dinner? (before/after)
	Fragmentation of free time for exercise	The degree to which a person has free time that is not interrupted by competing activities.	A person has one hour of free time but it is frequently interrupted by obligatory activities, such as child care.	To what extent is your free time interrupted by obligatory activities.
	Routine/regularity of free time for exercise	The consistency of duration, frequency and timing of free time for exercise.	A person has free time only on Sundays each week.	To what degree does your free time occur at the same time each day? (not at all—a great deal)
	Synchronisation of free time for exercise with internal and external rhythms	The alignment of a person's free time (duration, frequency and timing) with internal temporal rhythms (eg, circadian rhythm, menstrual cycle) or external temporal rhythms (social, institutions, cultural, environmental).	A person has free time in the morning, whereas their partner's free time is in the evening.	To what degree does your free time align with your partner's free time? (not at all—a great deal)
	Ability for polychronic use of free time	A person's ability to simultaneously engage in one or more activities in addition to exercise.	A person has time that involves activities that can be done simultaneously with exercise (eg, talking on the phone and walking).	To what degree can your time be used for completing multiple activities at once that includes exercise? (not at all—a great deal)
	Total duration of exercise	The total amount of time a person spends exercising in a given period (eg, day, week, month).	A person exercises for 150 minutes a week.	In a typical week, how long do you spend exercising?
	Exercise frequency	How often a person exercises in a given period (eg, day, week, month).	A person exercises on 5 days a week.	How many times per week do you exercise for at least 20 min?
	Duration of an exercise session	The amount of time a person spends on a single exercise session.	A person spends an average of 30 min in an exercise bout.	What is the typical amount of time you spend in an exercise session?
	Timing of exercise	Time of the day when a person exercises.	A person exercises in the mornings only.	At what time of the day do you typically exercise?
	Sequencing of exercise	Timing of exercise in relation to other activities.	A person exercises after they put their child to bed.	Do you typically exercise before work or after work?
Routine/regularity of exercise	The consistency of duration, frequency and timing of exercise.	A person exercises every Saturday and Sunday morning.	Do you typically exercise on the same days each week?	
Synchronisation of exercise with internal and external rhythms	The occurrence of a person's exercise (duration, frequency and timing) with internal temporal rhythms (eg, circadian rhythm, menstrual cycle) or external temporal rhythms (others, institutions, cultural, environmental).	A person exercises at a time that their partner also exercises.	Do you typically exercise at the same time at your partner or not?	
Collateral time cost of exercise	The time required to invest into exercise beyond the time spent exercising (eg, the time required to get ready for exercise or drive to the gym).	A person takes 30 min to initiate and conclude their exercise (ie, get dressed, shower, etc).	How much time do you spend initiating exercise (eg, getting changed, transport, etc.)?	



Temporal dimensions of exercise

and programmes), macrosystem (eg, values, social norms, traditions pertaining to exercise) and chronosystem. The fifth level, the chronosystem, is especially interesting in how it pertains to the EXPERT model. Acknowledging the influence of this system on the EXPERT model factors signifies that the temporal aspects of exercise will themselves be influenced by an individual's course of life and life transitions, seasonal changes and societal changes over time. The temporal aspects of exercise may also be influenced by personal characteristics, such as sociodemographic characteristics, physical health, time-use preferences/interests and psychological traits.

DISCUSSION

To unpack the notion of the 'lack of time' and provide researchers and practitioners with a framework and platform from which to study and promote exercise, we developed the EXPERT model encompassing 31 factors within four temporal categories: (1) temporal preferences and needs for exercise (ie, when and how long does an individual need/want to exercise), (2) temporal autonomy for exercise (ie, autonomy in scheduling free time for exercise), (3) temporal conditions for exercise (ie, available time for exercise) and (4) temporal dimensions of exercise (ie, use of time for exercise). The EXPERT model provides a comprehensive conceptualisation and precise definitions of temporal factors related to exercise, which may facilitate more systematic and targeted research and practice on this topic.

The model includes some factors that are theoretical in nature, warranting research and other factors with empirical support. Within the model's 'temporal preferences and needs' category, for example, data support the importance of alignment of exercise time with an individual's timing preferences for exercise adherence⁴⁵ and as a mediator between exercise and health outcomes.⁴⁶ Regarding 'temporal autonomy for exercise', the importance of perceived control over one's schedule is gaining empirical support as an important determinant of exercise. Calderwood *et al*,¹⁹ for example, demonstrated that perceptions of control over leisure time were related to engagement in PA in a sample of working single mothers. The factors within the temporal autonomy category of the EXPERT model may assist a more precise exploration of this phenomenon. For example, is autonomy over total amount of free time or autonomy over timing of free time periods more influential? Furthermore,

multiple factors within 'temporal conditions for exercise' (ie, category 3 of the EXPERT model) have empirical support. The importance of an individual's total amount of free time, in particular, is supported by previous findings.^{14 47–49} The importance of timing of free-time,⁵⁰ fragmentation of free-time²⁷ and routine/regularity of free time, or lack thereof,⁵¹ are also gaining attention in the literature. Other factors within this category, such as synchronisation of free time with others, may be promising avenues of research. Finally, multiple factors within the 'temporal dimensions of exercise' category are supported in the literature, while others require consideration in future research. An individual's total duration of exercise, exercise frequency and duration of an exercise session have long been the hallmark temporal characteristics of exercise, as reflected in how we prescribe,³¹ measure and report on exercise and PA.^{20 52} The total duration of exercise and PA has also been in the focus of studies in the emerging field of time-use epidemiology.^{53 54} Recently, the *timing* of exercise is gaining attention. While the role of time-of-day for exercise on health outcomes is inconclusive,⁵⁵ when aligned with one's exercise timing preference, it appears important for adherence⁴⁵ and outcomes.⁴⁶ The significance of consistency of exercise²³ and synchronisation of exercise time with that of others are also empirically supported.⁴⁸ Other temporal dimensions of exercise remain less studied and may be a focus of future studies such as the influence of sequencing of exercise with other behaviours (eg, before and after meals) and the collateral time cost of exercise.

Implications for research and practice

The implications of the EXPERT model extend across both research and practice (table 4). From a research perspective, the model may prompt and guide a more refined and comprehensive measurement of temporal dimensions of exercise and time use in general that would more accurately capture the complexities of how time relates to exercise. The temporal factors defined in the EXPERT model can be explored as determinants of exercise participation (eg, how autonomy over timing of free time periods predicts exercise participation) or other outcomes (eg, how routine/regularity of exercise predicts mental well-being). A comprehensive understanding of which temporal characteristics determine exercise participation may contribute to an understanding of 'time wealth for exercise', a collective of

Table 4 Implications for research and practice

Application	Description
Practice	<ul style="list-style-type: none"> ▶ Comprehensive temporal assessment: conducting detailed assessments of individuals' temporal preferences, scheduling autonomy and free-time conditions before exercise programming may help ensure tailored and realistic exercise plans that align with personal preferences and schedules. ▶ Expanding the 'T' of SMART exercise goals: incorporating detailed temporal elements from the exercise participation explained in relation to time (EXPERT) model into goal setting, including specific times of day for exercise, the consistency of routines and alignment with natural and social rhythms, may enhance goal specificity and achievability. ▶ A tool for motivational interviewing: the EXPERT model may assist motivational interviewing interventionists by providing a framework to fully explore and 'disentangle' an individual's barrier of the 'lack of time' for exercise. ▶ Personalised exercise scheduling: The EXPERT model, perhaps with the assistance of technology such as artificial intelligence, could enable the development of highly customised exercise schedules that reflect individuals' unique temporal preferences, autonomy and conditions, thus facilitating higher adherence and satisfaction.
Research	<ul style="list-style-type: none"> ▶ Improved and expanded measurement: the model may encourage the creation of novel measures or the expansion of current measures to encompass a broad array of temporal factors potentially relevant to exercise. ▶ Novel temporal determinants of exercise: the model may elucidate new avenues for research that examines the intricate ways temporal factors influence exercise behaviour. ▶ Test interventions targeting 'temporal targets': the model may encourage and guide the design and evaluation of novel interventions that specifically address temporal aspects of exercise, such as enhancing autonomy in scheduling and improving temporal conditions for exercise. ▶ Investigate the impact of temporal dimensions of exercise on adherence and outcomes: The model's fourth category, temporal dimensions of exercise, provides a framework for examining how temporal dimensions of exercise (eg, timing: morning vs evening exercise or sequencing: before or after screentime) influence adherence rates and various outcomes of PA and exercise.

temporal factors most pertinent to exercise participation. Studies conducted according to the EXPERT model may be relevant for designing individualised approaches to exercise promotion and for developing 'just in time' interventions that leverage critical moments when individuals are most receptive to engaging in exercise.⁵⁶ The model may also be used as a framework to help elucidate specific temporal elements obscured within the barrier of the 'lack of time' for exercise. For individuals, questioning guided by the EXPERT model may unravel their barrier of the 'lack of time' revealing, perhaps, a lack of intention to exercise to be the culpable factor.

Limitations

Conceptually, the development of the EXPERT model faced inherent limitations due to the complexity of conceptualising time, a highly complex topic deeply intertwined with the nuances of daily life. This necessitated the setting of boundaries, a 'universe of factors',³² which may have excluded other temporal factors relevant to exercise. Relatedly, the temporality of exercise is deeply intertwined with other factors; time and exercise have a dynamic (ie, changing across time) and context-dependent relationship. To counteract this, situating the model within a broader social ecological model was essential. Another of the model's conceptual limitations is the complexity and subjectivity in conceptualising time—a fundamental yet abstract construct whose definition and very existence spark considerable philosophical and scientific debate. This complexity introduces a degree of ambiguity or 'fuzziness' into the model's factors, particularly evident in concepts like 'free time'. The debate around 'free time', for example, raises the issue of viewing labour as a compulsory activity versus a choice. Moreover, the subjective nature of time perception among individuals—shaped by cultural, social and personal factors—adds another layer of complexity to accurately defining and measuring time in relation to exercise behaviour. Acknowledging these debates, we accepted a certain level of ambiguity as a trade-off for pragmatism and applicability in developing the EXPERT model. Moreover, recognising that time is a complex concept subject to various cultural factors, it should be noted that the cultural and social representativeness in both the existing literature (ie, synthesised in the umbrella review and targeted review) and the Delphi and consultation panels may have constrained the generalisability of our model. Future research should focus on cross-cultural validations of the EXPERT model to verify its generalisability.

The use of umbrella review to identify potential time-related determinants, correlates and barriers to PA and exercise may have precluded identification of some relevant individual studies. However, the umbrella review was deemed to be the method of choice for this purpose, due to a large number of individual studies on the topic. Moreover, the quality of the included systematic reviews was not evaluated as the intention at this stage was 'idea generation'³²; this reinforces the need for validation and testing of the components of the EXPERT model. Finally, seven of the 25 reviews included in the umbrella review did not include a reference to time-related factors. This may be due to the limited scope of some of the reviews or a focus on specific population groups for whom temporal factors may not have been studied as determinants of PA and exercise before the review. However, the inclusion of these reviews was necessary to get a proper insight into the representation of time-related factors in studies on determinants, correlates and barriers to PA and exercise.

CONCLUSION

Recognising that a lack of time is a key barrier to exercise and to facilitate more targeted and systematic research and practice on this topic, the EXPERT model provides a comprehensive framework for understanding the multi-dimensional nature of time as it relates to exercise participation. It moves beyond the simplistic notion of 'lack of time' and delves into the complexity of how exercise is characterised and determined by various temporal factors. The EXPERT model offers a valuable framework for researchers to explore how exercise can be defined by and is influenced by temporal factors. Ultimately, future studies conducted according to the EXPERT framework may inform the development of more effective interventions and strategies that recognise the multifaceted temporal nature of exercise.

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