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## **Mediators of behaviour change maintenance in physical activity interventions for young and middle aged adults: a systematic review**

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Supplementary file 2: Definitions of putative mediators and domains of the Theoretical Domains Framework

<b>Putative Mediators/Domain<sup>1</sup></b>	<b>Definition</b>	<b>Brief (theoretical) explanation</b>	<b>Relevant behaviour change theories</b>
<b><i>Knowledge</i></b>	<i>An awareness of the existence of something [1].</i>		
Awareness of physical activity level/benefits	The individual's knowledge of Public Health recommendations [2] and their self-rated compliance with the guideline.	It may be difficult for the individual to evaluate the adequacy of their compliance to complex health behaviours in order to gain health benefits. E.g. PA may include a variety of different activities carried out at different times and places throughout the day and some people may not even be aware that they are insufficiently active. Interventions which increase awareness may play a role in translation of intentions into behaviour [3].	
<b><i>Skills</i></b>	<i>An ability or proficiency acquired through practice [1].</i>		
Self-regulatory skill use for physical activity	The individual's ability to set specific and achievable goals, use effective strategies for reaching goals, and self-monitor to evaluate discrepancies between their performance and their self-set standard.	The individual is more likely to adopt and maintain a behaviour if they monitor and regulate it and employ strategies to overcome barriers [4]. E.g. SCT indicates that the process of self-regulation includes three sub-processes: self-observation, self-judgement and self-reaction [5,6].	SCT [5]
<b><i>Social/Professional role and identity</i></b>	<i>A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting [1].</i>		
Physical activity integrated in the self-concept	The 'self-concept' is defined as "beliefs and images about oneself and feelings about these" [7]. Integration of PA in the self-concept involves modification of a person's self-identity to incorporate the notion of being a physically active person. Hence PA becomes less about "what one does" and more about "who one is" [8].	Several behaviour change theories advocate that the self-concept is an important determinant of behaviour. E.g. PRIME theory suggests that as a prominent source of wants and needs, the self-concept influences motivation for behaviour through the medium of self-control [9]. New behaviour is maintained when the want and need to maintain it is	SCT [5] SDT [10–12] PRIME Theory of Motivation [9]

<sup>1</sup> Explanations are provided for each domain of the Theoretical Domains Framework (bold italics) and individual putative mediators. Mediators are organised according to domain.

		greater than the want and need to revert. Under SDT, integrated regulation is one of the more intrinsic forms of motivation involving enactment of behaviour in line with one's self-concept. This occurs when the behaviour satisfies basic psychological needs for competence, autonomy and relatedness to others. Furthermore, the individual is more likely to maintain behaviour that is intrinsically motivated.	
<b>Beliefs about capabilities</b>	<i>Acceptance of the truth, reality, or validity about an ability, talent, or facility that a person can put to constructive use [1].</i>		
Physical activity self-efficacy	Self-efficacy is defined as "beliefs in one's capabilities to organise and execute the courses of action required to produce given attainments" [13]. PA self-efficacy refers directly to the individual's conviction in their ability to perform particular physical activities under specific circumstances [14].	Without conviction in their ability to achieve desired outcomes by their actions, the individual has little incentive to act to change behaviour. It is primarily through these beliefs that individuals decide which behaviours to engage in and how much effort to exert to persevere when faced with challenges, setbacks and failure experiences [15–17].	Self-efficacy Theory [13] SCT [5] TTM [18]
Perceived behavioural control	The individual's perception of their own ability to execute the behaviour and their control beliefs (i.e. weighing of the elements that are capacitating or debilitating of the behaviour) [7].	Greater perceived behavioural control should increase the individual's intention to perform the behaviour.	SCT [5] TPB [19,20]
<b>Optimism</b>	<i>The confidence that things will happen for the best or that desired goals will be attained [1].</i>		
Attitude to physical activity (e.g. instrumental/affective)	The extent to which the individual has a favourable or unfavourable evaluation of the behaviour. It is determined by their behavioural beliefs associated with possible outcomes of attempting to perform the behaviour [7]. It incorporates beliefs about outcomes associated with wellbeing (instrumental), and feelings/emotions (affective).	A more positive attitude regarding the possible outcomes of the behaviour should increase the individual's intention to perform the behaviour.	TPB [19,20]
<b>Beliefs about consequences</b>	<i>Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation [1].</i>		
Outcome expectancies	The costs and benefits which the individual expects to occur from the performance (or non-performance) of the behaviour [21].	Individuals behave in ways expected to yield favourable consequences and avoid behaviours for which negative outcomes are expected. Outcome expectancies occur as a result of the interaction between anticipation that the outcome will occur and the value placed on the outcome by the individual.	HAPA [22,23] SCT [5] TTM [18]

		Bandura defines three different types of outcome expectancies for physical effects (i.e. bodily sensations), social effects (i.e. peer approval or disapproval) and self-evaluation (i.e. how one expects to feel about oneself) resulting from the behaviour with positive effects serving as incentives (negative effects serving as disincentives) [16].	
Perceived benefits of physical activity/Response efficacy	The individual's perception that adopting and maintaining the behaviour will result in desirable benefits. Examples include enjoyment, social contact, psychological benefits, opportunities for competition, body image and health benefits) [24].	The greater the individual's perception that benefits will result from enacting the behaviour, the more likely they are to adopt and maintain it.	Health Belief Model [25] TTM [18]
Outcome satisfaction	The extent to which the outcomes, resulting from the change in behaviour, meet or exceed the individual's expectations. <i>See outcome expectancies.</i>	The greater the individual's satisfaction with the outcomes of behaviour change, the stronger is their conviction that implementing the behaviour change was the right thing to do, and the more likely they are to maintain it [26].	Rothman's Theory of Behavioural Maintenance [26] PAM [27]
<b>Intentions</b>	<i>A conscious decision to perform a behaviour or a resolve to act in a certain way [1].</i>		
Intention to change physical activity	The individual's motivation to perform the behaviour: their willingness to try to perform the behaviour and the effort they plan to exert [7].	Intentions take precedence in the early stage of behaviour change. Social cognitive theories frequently specify that intentions are the best direct predictors of behaviour change. However, individuals do not always act in accordance with their intentions due to unforeseen barriers or temptations, giving rise to an "intention-behaviour" gap [28].	HAPA [22,23] SCT [5] TPB [19,20]
Commitment	Making a commitment involves an affirmation of intent to change the behaviour [29]. The individual's level of commitment includes the importance of changing the behaviour to the individual, their confidence in their ability to change the behaviour if they decided to and the extent to which they are trying to change the behaviour [30].	Individuals want to maintain a consistent and positive self-image [31], and will therefore keep commitments to avoid reputational damage or cognitive dissonance (i.e. tension existing between two simultaneous and conflicting ideas) [32].	Cognitive Dissonance Theory [32] PAM [27]
Stage of change for physical activity/Motivational readiness for physical activity	The TTM [18] stage of behaviour change that the individual is in. The TTM defines the process of behaviour change as occurring in five sequential stages of change: Precontemplation (i.e. not planning	Individuals in the later stages of change are more likely to have changed their behaviour and to maintain the change. However, progress through the stages is not typically achieved linearly as individuals relapse	TTM [18]

	to change within the next six months); Contemplation (i.e. thinking about changing within the next six months); Preparation (i.e. taking steps towards changing within the next month); Action (i.e. attempting change) and Maintenance (i.e. maintained change for at least six months) [7].	and revert to earlier stages. If the individual is to progress through the stages again, they must learn from their experiences.	
Experiential/Cognitive processes of change	Five processes of behaviour change experienced by the individual in moving between the TTM [18] stages of Precontemplation and Contemplation. These include: Consciousness raising (i.e. increasing awareness and information processing about the problem and oneself); Dramatic relief (i.e. experiencing and releasing emotions about the problem and solution); Environmental re-evaluation (i.e. assessing the impact a personal behaviour might have on the social environment); Self re-evaluation (i.e. assessing the self-image in relation to the problem); Self-liberation (i.e. having the belief that change is possible and committing to it) [7].	The TTM [18] states that these processes are mediators between the Precontemplation and Contemplation stages of change. Individuals who implement these processes are more likely to move from Precontemplation to Contemplation.	TTM [18]
Behavioural processes of change	Five processes of behaviour change experienced by the individual in moving between the TTM [18] stages of Action and Maintenance. These include: Helping relationships (i.e. forming relationships with people who are supportive of the problem and behaviour change); Counter conditioning (i.e. adopting healthy behaviours as substitutes for problem behaviours); Stimulus control (i.e. altering the environment so that cues for healthy behaviour are increased and cues for problem behaviours are decreased); Reinforcement management (i.e. reward for healthy behaviour or punishment for problem behaviour); Social liberation (i.e. observing social, policy or environmental changes that facilitate behaviour change) [7].	The TTM [18] states that these processes are mediators between the Action and Maintenance stages of change. Individuals who implement these processes are more likely to move from Action to Maintenance.	TTM [18]
Intrinsic motivation for physical activity	An individual is intrinsically motivated to perform a behaviour when they carry it out due to inherent interest, values or enjoyment. Conversely, behaviour	Behaviour that is intrinsically motivated is more likely to be maintained since it fulfils basic psychological needs for competence, autonomy and relatedness to	SDT [10–12]

	that is extrinsically motivated is performed to attain some outcome separable from the behaviour [7].	others [7]. When one is intrinsically motivated, they are characterised by greater productivity, creativity, spontaneity, cognitive flexibility, and perseverance [10].	
Identified regulation	One of the more internalised forms of motivation on the SDT continuum [33] referring to behaviour which is freely enacted based on the perceived value of its outcomes to the individual [33].	<i>See Intrinsic motivation for physical activity.</i>	SDT [10–12]
Self-determined motivation/behaviour beliefs	Under SDT, individuals differ in their motivational tendencies to perform a behaviour. For example, behaviour differs in the degree to which it is autonomous/internal or controlled/external. The process of internalisation is represented by a move along a continuum (amotivation, external regulation, introjected regulation, identified regulation, integrated regulation, intrinsic motivation). Intrinsic motivation is further subdivided according to the individual's intrinsic motivation to learn, accomplish tasks and experience sensations.	<i>See Intrinsic motivation for physical activity</i>	SDT [10–12]
<b>Goals</b>	<i>Mental representations of outcomes or end states that an individual wants to achieve [1].</i>		
Goal setting	Individuals set goals to achieve highly valued outcomes. They set large distal goals and plan how they will achieve them by setting smaller, more proximal goals.	Individuals adopt personal standards and regulate their behaviour by self-evaluation. Whilst distal goals “set the course of personal challenge”, more proximal goals (or intentions) guide action and enlist motivation in the present to initiate change [21].	SCT [5] PAM [27]
<b>Memory, attention and decision processes</b>	<i>The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives [1].</i>		
Decisional balance (pros/cons)	An individual's decisional balance is their weighing of the pros (i.e. advantages and positive aspects) and cons (i.e. disadvantages and negative aspects) of behaviour change [7].	Movement between the TTM [18] stages of change is influenced by the individual's decisional balance. Progression is likely to result if the individual perceives more pros associated with behaviour change. They are more likely to revert if they perceive more cons associated with behaviour change.	TTM [18] PAM [27]
Pros	An individual's evaluation of the advantages and positive aspects of behaviour change.	<i>See Decisional balance (pros/cons)</i>	TTM [18] PAM [27]
Cons	An individual's evaluation of the disadvantages and	<i>See Decisional balance (pros/cons)</i>	TTM [18]

	negative aspects of behaviour change.		PAM [27]
<b>Environmental context and resources</b>	<i>Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour [1].</i>		
Perceived barriers to physical activity/Barrier self-efficacy	An individual's perception of the barriers to behaviour change (e.g. time constraints, other commitments, expense, motivation) and their ability/willingness to overcome them.	An individual's belief in their ability to cope with barriers when they arise (i.e. barrier self-efficacy) is grounded in the stress and depression they experience in taxing situations. E.g. high levels of barrier self-efficacy enable people to transform environments they perceive as threatening into benign ones. Negative emotions are also partially alleviated when the individual forms supportive relationships with valued others. Under SCT [5], perceived barriers influence setting of behavioural goals as people will do what they think will succeed and avoid what they think will fail. Individuals with higher barrier self-efficacy employ problem solving and are less likely to lapse or relapse when barriers arise [17].	Health Belief Model [25] SCT [5] PAM [27]
Perceived environment	An individual's perception of the environment in which the behaviour is performed and their evaluation of the extent to which it is facilitating or impeding of the behaviour.	Individuals who perceive that their environment is more facilitating of behaviour change are more likely to initiate and maintain behaviour change. Furthermore, under SCT [5], perceptions of the environment mediate the effect of self-efficacy on behaviour as efficacious individuals are more likely to form supportive environments and to respond to positive environmental cues for behaviour [17].	SCT [5] PAM [27]
Perceived environment (home)	The availability of supplies or pieces of equipment (e.g. aerobic equipment, weight-lifting equipment, workout videos) at the individual's place of residence which can be used for PA [34].	<i>See Perceived environment.</i>	
Perceived environment (facilities)	The presence of convenient facilities for PA (e.g. basketball courts, bike lanes, trails, health spas, gyms, public parks) within a 5-minute drive or walk from the individual's workplace or home [34].	<i>See Perceived environment.</i>	
<b>Social influences</b>	<i>Those interpersonal processes that can cause individuals to change their thoughts, feelings, or behaviours [1].</i>		
Social support (unspecified)/Social influences	An individual's perception that others within their social circle (e.g. friends, family) are supportive of the	Individuals with a strong sense of social efficacy to form relationships that bring satisfaction to one's life	SCT [5]

	behaviour change.	have reduced susceptibility to stress, depression and physical illness. Evidence suggests that social support enhances health promoting behaviour through increased coping efficacy (i.e. by reducing negative emotions). Social support and self-efficacy have a bi-directional relationship [16].	
Social support (friends/community)	An individual's perception that friends or members of their community are supportive of the behaviour change.	<i>See Social support (unspecified)/Social influences</i>	SCT [5]
Social support (family)	An individual's perception that members of their family are supportive of the behaviour change.	<i>See Social support (unspecified)/Social influences</i>	SCT [5]
Social support (rewards and punishment)	Rewards and punishment for PA from family members. Higher scores indicate greater frequency of behaviours [35].	<i>See Social support (unspecified)/Social influences</i>	SCT [5]
Social support (instrumental/institutional)	An individual's perception that the institution to which they belong (usually through which the intervention is implemented) is supportive of the behaviour change and offer support in changing the behaviour.	<i>See Social support (unspecified)/Social influences</i>	SCT [5]
Injunctive/Subjective norms	Injunctive norms refer to an individual's beliefs about what ought to be done [36]. They are behaviours which the individual perceives as being approved of by other people.	Individuals seek to gain approval from important others and avoid social sanctions by engaging in behaviours they perceive to be socially acceptable [7].	SCT [5] Theory of Normative Social Behaviour [37] TPB [19,20]
Sports partner	A sports partner is a member of the individual's social circle with whom they exercise regularly.	Having a sports partner can promote behaviour change by vicarious learning (i.e. learning by observing others) [38], providing encouragement, as well as being a source of social support.	
Descriptive norms/Social modelling	Descriptive norms refer to an individual's perception of how other people are behaving and whether or not these behaviours are approved of.	By vicarious learning [38], individuals observe the successes and failures of important others and replicate their behaviour. They adopt what they have seen succeed/approved of and avoid what they have seen fail/disapproved of.	SCT [5] Theory of Normative Social Behaviour [37]
<b>Emotion</b>	<i>A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event [1].</i>		
Revitalisation	One of the four feeling states, assessed by the EFI [39] that an individual experiences with bouts of PA.	Human motivation can be described in terms of wants (i.e. mental images of a situation/event and	EFI [39] PRIME Theory of



	Revitalisation refers to a measure to assess how energetic, revived and refreshed one feels during/following PA.	anticipated feelings of pleasure or satisfaction) and needs (i.e. anticipated relief from mental or physical discomfort from a situation/event) [7,9]. When an individual experiences (and remembers) feelings of pleasure in relation to PA, they are more likely to increase their intentions, implement and maintain behaviour change. Conversely, when an individual experiences (and remembers) negative feelings in relation to PA, they are less likely to increase their intentions, implement and maintain behaviour change [40–44].	Motivation [9]
Positive engagement	One of the four feeling states, assessed by the EFI [39] that an individual experiences with bouts of PA. Positive engagement refers to a measure to assess how enthusiastic, up-beat and happy one feels during/following PA.	<i>See Revitalisation</i>	EFI [39] PRIME Theory of Motivation [9]
Tranquillity	One of the four feeling states, assessed by the EFI [39] that an individual experiences with bouts of PA. Tranquillity refers to a measure to assess how calm, peaceful and relaxed one feels during/following PA.	<i>See Revitalisation</i>	EFI [39] PRIME Theory of Motivation [9]
Physical exhaustion	One of the four feeling states, assessed by the EFI [39] that an individual experiences with bouts of PA. Physical exhaustion refers to a measure to assess how fatigued, worn out and tired one feels during/following PA.	<i>See Revitalisation</i>	EFI [39] PRIME Theory of Motivation [9]
Enjoyment	The extent to which the individual likes/dislikes engaging in the behaviour (e.g. how fun, energising, frustrating, interesting they find it and their sense of accomplishment).	Individuals with high levels of expected enjoyment increase their intentions to engage in PA [45]. When individuals anticipate positive emotions, they are more likely to implement and maintain behaviour change [40]. When they anticipate negative emotions they are less likely to increase their intentions or implement behaviour change [43].	
Mood	An individual's levels of Positive Affect and Negative Affect. Positive Affect reflects how enthusiastic, active and alert the individual feels. Negative Affect incorporates a variety of aversive mood states (e.g.	There is a bi-directional relationship between mood and PA behaviour [47]. Individuals with higher levels of Positive Affect and lower Negative Affect are more likely to implement and maintain behaviour change.	

	anger, disgust, guilt, fear). High Positive Affect includes high energy levels, concentration and engagement. Low Positive Affect is a state of sadness and lethargy. Low Negative Affect is characterised by calmness and serenity [46].	Increased PA leads to further enhancements in mood.	
Severity	An individual's perception of how serious the negative consequences of engaging/not engaging in the behaviour will be (e.g. contracting disease). This includes emotional arousal associated with thoughts of the possible outcome and associated difficulties (e.g. health and job implications). Perceived severity depends on knowledge of the consequences and perceived threat [7].	An individual who perceives greater severity in the negative consequences of not engaging in the behaviour is more likely to change their behaviour.	HAPA [22,23] Health Belief Model [25] Protection Motivation Theory [48]
Vulnerability	An individual's perception of their level of risk for the negative consequences of engaging/not engaging in the behaviour. Perceived vulnerability depends on knowledge of the consequences and perceived threat [7].	An individual who perceives that they have greater vulnerability to the negative consequences of not engaging in the behaviour is more likely to change their behaviour.	HAPA [22,23] Health Belief Model [25] Protection Motivation Theory [48]
Fear	An anticipatory emotion experienced by an individual reacting to the possibility of danger or harm [49]. Fear arousal influences how the individual appraises threat (i.e. makes a judgement on the likelihood of a negative outcome) and severity [7].	An individual who perceives greater risk of danger/harm (from possible negative outcomes) will change their behaviour.	HAPA [22,23] Health Belief Model [25] Protection Motivation Theory [48]
Autonomy/Perceived choice	One of the three basic human psychological needs (i.e. the need to feel willingness and choice when acting [50]) which need to be fulfilled in order to allow the individual to experience vitality, self-motivation and well-being [12].	When a behaviour causes basic human psychological needs to be fulfilled, it becomes intrinsically motivated and is therefore more likely to be maintained long-term [7].	SDT [10–12]
Competence	One of the three basic human psychological needs (i.e. the need to feel effective when dealing with the environment [50]) which need to be fulfilled in order to allow the individual to experience vitality, self-motivation and well-being [12].	<i>See Autonomy</i>	SDT [10–12]
Relatedness	One of the three basic human psychological needs (i.e.	<i>See Autonomy</i>	SDT [10–12]

	the need to interact with, be connected to and experience caring for others [50]) which need to be fulfilled in order to allow the individual to experience vitality, self-motivation and well-being [12].		
Total needs satisfaction	The three basic human psychological needs (autonomy, competence, relatedness) which need to be fulfilled in order to allow the individual to experience vitality, self-motivation and well-being [12].	<i>See Autonomy</i>	SDT [10–12]
Depression	A common mental disorder incorporating persistent sadness, loss of interest in activities the individual usually enjoys and inability to complete daily activities for at least two weeks [51].	<i>See Mood</i>	
Perceived stress	The degree to which certain situations are perceived by the individual as being stressful.	<i>See Mood</i>	
<b>Behavioural regulation</b>	<i>Anything aimed at managing or changing objectively observed or measured actions [1].</i>		
Planning (Action)	Action plans are detailed specifications of how when and where the behaviour will be performed [7].	An individual, having formed the intention to change their behaviour, will implement plans to ensure the translation of intentions to behaviour. The quality and quantity of planning depends on the individual's perceived self-efficacy for behaviour change. Maintenance depends on their use of self-regulatory processes.	HAPA [22,23] SCT [5]
Planning (Strategic)	Strategic plans specify how the behaviour will be carried out (e.g. type of PA).	<i>See Planning (Action)</i>	HAPA [22,23] SCT [5]
Coping planning	Coping plans involve the anticipation of potential barriers to behaviour change and the development of choices to overcome barriers [7].	<i>See Planning (Action)</i>	HAPA [22,23] SCT [5]
Physical activity habit	Habits are formed when the behaviour becomes regular, automatic and ingrained in the self-concept. By contrast, performance of a new behaviour requires conscious decision making [52,53].	Behaviour carried out as habit, (being intentional, controllable to an extent and efficiently executed without awareness) [53] is more likely to be maintained as it is automatically triggered by environmental cues [52,53].	Verplanken & Orbell's Theory of Habit [53] HAPA [22,23] Triandis' Theory of Interpersonal Behaviour [54]

EFI: Exercise-Induced Feeling Inventory; HAPA: Health Action Process Approach; PA: Physical activity; PAM: Physical Activity Maintenance Theory; PRIME: Plans, responses, impulses, motives and evaluations; SCT: Social Cognitive Theory; SDT: Self Determination Theory; TPB: Theory of Planned Behaviour; TTM: Transtheoretical Model.

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