Abstract

WHO's (2022) physical activity (PA) report shows that about 1.4 million adults are less inactive, partly due to technological advancements and COVID-19 restrictions. Consequences of physical inactivity are found to have devastating implications for physiological and psychological health and well-being, resulting in a global fiscal dent of over US$27 billion annually. To this end, this report reviews relevant literature that analysed PA behaviour, primarily in young adults, such as the BCW (COM-B) and Transtheoretical Model, to identify and stimulate key PA behavioural components. Findings indicate that self-efficacy, exercise self-identity, and self-management are essential to stimulating PA. Thus, based on the BCW framework, intervention functions such as education, incentivisation, and enablement are recommended with support from the communication/marketing and service provision policy categories. Wearables and smartphone technology are also considered to facilitate the delivery of the recommended interventions. Limitations and other strategies for sustainable implementation are discussed.

Introduction

The World Health Organization has classified health and well-being outcomes into communicable, noncommunicable diseases, and mental health conditions (WHO, 2024). Notably, the WHO has reported that regular physical activity (PA) can significantly reduce the risk of developing a noncommunicable disease (NCD). However, global estimates reveal a staggering fact that 1.4 billion adults worldwide fail to meet the recommended level of PA to improve and protect their health (Guthold et al., 2016). This widespread inactivity has led to a decline in global health and has severe economic implications. NCDs, such as Ischaemic Heart Disease, a potential consequence of a decline in PA, was a leading cause of death between 2000-2019 (WHO Report, 2022). This trend has also resulted in a disparity between life and healthy life expectancy (HALE) (WHO, 2022). The WHO (2022) predicts that almost 500 million new

preventable NCDs will occur between 2020–2030, incurring treatment costs of around US$27 billion annually.

The advancement of technology and the COVID-19 pandemic played significant roles in the decline of PA in the UK (Hallal et al., 2012; McCarthy et al., 2021). Although advancement in technology comes with many benefits, its negative implications on health have contributed to the global epidemic of NCDs (Hallal et al., 2012). A meta-analysis found that PA has a positive psychological and physiological impact on healthy and clinical populations (including affective disorder population) across diverse demographics (Guszkowska, 2004; Sharma et al., 2006; Uusitupa & Ursula, 2020; Byrne & Byrne, 1993). For example, Byrne and Byrne (1993) found that engaging in aerobic exercises reduces depression and anxiety and enhances mood.

This Report seeks to stimulate vigorous-to-moderate PA in healthy young adults based on empirically-validated behavioural change techniques (BCT). Based on the NHS's recommendation, our target behaviour is to get young adults to engage in either 75 minutes of vigorously-intense or 150 minutes of moderately-intense activity weekly spread evenly between four-to-five days (NHS). Michie et al. (2009) suggests that BCTs effectively increase PA and healthy eating in adults. Thus, this report will introduce and empirically review how the behaviour of engaging in PA has been analysed with the *Behavioural Change Wheel (BCW) and the Transtheoretical Model (TTM).* Based on the findings, the report will recommend interventions to reach the target PA behaviour, including challenges, limitations, and potential strategies for successful intervention implementation.

Behavioural Models and Analysis of Physical Activity Behaviour

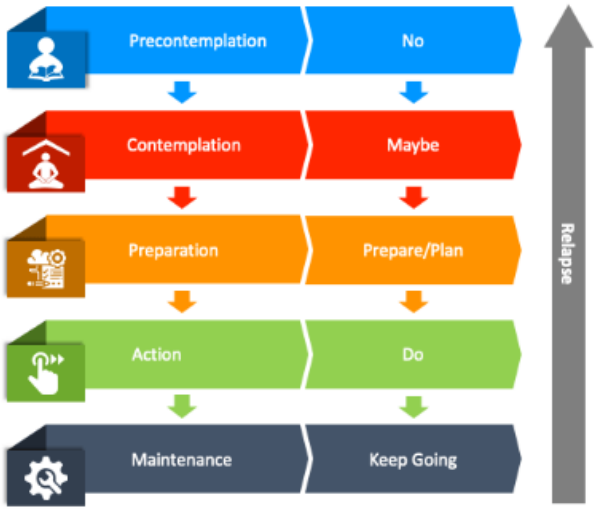
Model Description - COM-B & TTM

The BCW framework was a collaborative effort to design a comprehensive approach to facilitating behavioural change. At the centre of BCW is the COM-B model of behaviour. The COM-B specifies Capability (physical and psychological), Opportunity (social and physical) and Motivation (reflective and automatic) as the drivers of behaviour and is centred around the

principle of US Criminal Law (Michie et al., 2011). The model also posits that both Capability and Opportunity influence Motivation, making it the central mediator of the model. Therefore, Capability and Opportunity can both directly and indirectly influence behaviour. In addition to COM-B, the BCW framework includes nine intervention functions and seven policy categories that can support identified source components in COM-B. The TTM will support this report. TTM (Prochaska & DiClemente, 1982) is organised around five stages of change (Figure 1) with an acknowledgement that individuals experience relapse (backward progression). TTM also includes three core constructs (See Table 1).

Figure 1.

TTMs Stages of Change



Prochaska & DiClemente, 1982

Table 1.

TTMs Theoretical Constructs

Construct	Description
Decisional balance	Reflects an individual's perception of the importance of the pros and cons of exercise

Self-efficacy	Reflects the level of confidence one feels in one's ability to successfully exercise across challenging situations
Process of change	Reflect the frequency with which an individual engages in 10 specific cognitive and behavioural activities that facilitate stage progress

Note: Table is a summary of Lipschitz et al.'s (2015) description of TTM's constructs.

Although not as comprehensive as BCW (COM-B) (Mitchie et al., 2011), Bridle et al. (2005) found little evidence of TTM-based interventions. It also appears to share some similarities with COM-B, which encompasses self-regulation and affect (See Figure 2).

Figure 2.

A Breakdown of TTMs Process of Change Construct

Construct	Definition	Item Example
Experiential Processes of Change:		
Consciousness Raising	Increasing information about self and problem	I look for information related to exercise.
Dramatic Relief	Experiencing and expressing feelings about one's problems and solutions	I am afraid of the consequences to my health if I do not exercise.
Environmental Reevaluation	Assessing how one's problem affects physical environment	I think that regular exercise plays a role in reducing health care costs.
Self-reevaluation	Assessing how one feels and things about one-self with respect to a problem	I believe that regular exercise will make me a healthier, happier person.
Social liberation	Increasing alternatives for nonproblem behav-iors available in society	I am aware of more and more people who are making exercise a part of their lives.
Behavioral Processes of Change:		
Counterconditioning	Substituting alternatives for problem behav-iors	Instead of taking a nap after work, I exercise.
Helping relationships	Being open and trusting about problems with someone who cares	My friends encourage me to exercise.
Reinforcement management	Rewarding one's self or being rewarded by others for making changes	I try to think of exercise as a time to clear my mind as well as a workout for my body.
Self-liberation	Choosing and commitment to act or belief in ability to change	I tell myself that I can keep exercising if I try hard enough.
Stimulus Control	Avoiding or countering stimuli that elicit problem behaviors	I use my calendar to schedule my exercise time

Behavioural Analysis with COM-B

Several studies have examined PA behaviour with COM-B (Spence et al., 2021; Willmott et al., 2021; Silveira et al., 2021; Sofro et al., 2022; Howlett et al., 2017). For example, Spence et al.'s (2021) study examined how COVID-19 decreased PA. Findings indicated that physical opportunity (PO) and reflective motivational (RM) processes were key predictors of engaging in

different modalities of PA behaviour (recreation/sports activities). PO's predictive significance was reported to be primarily due to restrictions imposed by the COVID lockdown. The different contexts (such as disruptions in active transport used to provide the cues for automatic behavioural processes), however, required more conscious decision-making and engaging RM, such as being intentional about engaging in PA.

Similarly, Willmott et al. (2021) found that RM indicators such as *identity, positive affect, self-efficacy, and intentions* were strong indicators of motivation - which mediated the positive association of capability and opportunity on PA. In order of indicator strength - *habits, action control, and action planning (all psychological capabilities) and social support and descriptive subjective norms (all psychological opportunities)* - were also all significantly associated with PA. Howlett et al. (2017) also found capability and motivation to be critical drivers of PA behaviour. Similar to the two studies cited earlier, RM was also a strong mediator of capability. The strong indirect effect of capability on PA via motivation reflects the importance of habits (the strongest indicator of capability followed by self-monitoring and action planning) on motivation. Exercise self-identity (ESI) was also the strongest indicator of motivation (followed by self-efficacy and intentions). However, opportunity appears to have a small indirect effect on PA via motivation and no significant direct effect.

In another study, Silveira et al. (2021) found that both current and long-term PA were predicted by indicators such as intentions, self-efficacy, action control (AC), action planning (AP), and goal setting. Thus, psychological capability (PC) and RM, like in previously cited short-term studies, are key to stimulating PA. Although the study targeted individuals with Multiple Sclerosis, it still provides some evidence for how COM-B can explain the complexities of PA behaviour.

These findings suggest that young adults who identify as exercisers are more likely to develop habits, diligently plan their PA goals, and exert control over their implementation.

Importantly, identity stimulates motivation and plays a significant role in fostering competence (self-efficacy) and shaping intentions to engage in PA.

Also, since this report aims to get individuals into PA or from action to maintenance stage of PA, one expects intentions to already be average or high. Although intention alone might not stimulate PA as it could also (co)depend on individual differences and factors such as self-efficacy, self-regulation (AP & AC), or habits (Rhodes & Yao, 2015).

Behavioural Analysis with TTM

Romain et al. (2016) found that individuals in advanced SOC used both experiential and behavioural POC (see Figure 2) than those in pre-action stages. However, behavioural POCs had the largest effect size, suggesting that helping relations (social support), stimulus control (action control and planning), self-liberation (efficacy), and reinforcement management (incentivization) are promising POCs to stimulate PA. Nigg et al.'s (2019) longitudinal study had similar findings, with most individuals in advanced SOC reporting that behavioural constructs supported being in an advanced stage, including a reduction in barrier self-efficacy, reduced temptations, positive decisional balance, and low to moderate use of behavioural POCs. Similarly Lipschitz et al.'s (2015) longitudinal study found that maintainers (individuals who moved from action to maintenance) used all experiential and behavioural POCs at all three time points examined (baseline, 12 months, and 24 months). Participants reported this to have increased their self-efficacy and decisional balance. Interestingly, SE was reported to be higher in long-term periods and remained the same for maintainers, relapsers, and stable-non changes at baseline.

Intervention Recommendation

From the evaluation of the evidence, Table 2 shows the indicators that appear to be significantly consistent across both models and studies. However, this report will focus only on the RM and PC source components.

Table 2.

Mapping Relevant Indicators to BCW Source Components

Indicator	Associated BCW-Component
Identity	Reflective Motivation (RM)
Self-efficacy	
Intentions	
Action Planning/Goal Setting	Psychological Capability (PC)
Action Control/Self-Monitoring	
Habits	
External Support/Subjective Norms	Social Opportunity (SO)

Based on the BCW, a single intervention function (IF) could target multiple indicators or theoretical domain functions (TDF: A 14-list summary of theories of behaviour that often contain overlapping constructs) (Michie et al., 2011). For example, the education IF, concerned with increasing knowledge, can be targeted at both the PC and RM of the BCW component source (Michie et al., 2011). With this, it is essential to specify which of the indicators of COM-B components will be targeted and their associated IF. Before proceeding, it is pertinent to distinguish between the education and training IF. According to Michie et al.'s (2011) source definition, training is more related towards acquiring a skill to be competent in some art, occupation, or discipline, while education is not associated with either as it is just a systematic instruction or training process.

Figure 3.

Definitions of Intervention Functions (Michie et al., 2011) - Additional File 5

	Label	APA	OED
Interventions			
1.	Education	The process of teaching knowledge, skills and values	Systematic instruction or training
2.	Persuasion	Active attempt by one person to change another person's attitudes, beliefs or emotions associated with some issue, person, concept, or object	the addressing of arguments or appeals to a person in order to induce cooperation, submission, or agreement
3.	Incentivisation	Using an external stimulus, such as a condition or an object, that enhances or serves as a motive for behaviour	Arousing feeling, or inciting to action
4.	Coercion	The process of attempting to influence another person through the exercise of physical, psychological or social power	Constraint, restraint, compulsion; the application of force to control the action of a voluntary agent
5.	Training	Systematic instruction and practice by which an individual acquires competence in a specific discipline, talent, or vocational or recreational skills of activity	systematic instruction and exercise in some art, profession, or occupation, with a view to proficiency in it
6.	Restriction		Something that restricts a person or thing; a limitation on action
7.	Environmental restructuring		GOOGLE – restructuring-reorganizing or rearranging
8.	Modelling	A technique in which learning occurs through observation and imitation alone	The action or process of eliciting a mode of behaviour by example
9.	Enablement	Enablement: Encouraging or allowing people to meet their own needs and achieve desired ends	The process of rendering able, competent, or powerful/ source of help, information, strength, etc.

Intervention Theme 1: Developing Competency-Based Self-Efficacy based on Exercise Self-Identity

Although SE and ESI are placed as stand-alone indicators of psychological capability in this report, ESI is associated with SE and can be interpreted as perceptions of competence about performing PA (Vlachopoulos et al., 2011). Thus, it is intuitive to design interventions by integrating both indicators. Efforts to enhance competency-based self-efficacy will indirectly also enhance exercise identity; that is, improving the SE of a non-exerciser could transform them into an exerciser. However, Vlachopoulos et al. (2011) suggest that this could only be the case if efforts to bolster SE through instructional training are personalised to young healthy adults' current or reported ESI.

The recommended intervention will omit intentions. The reason for this is not far-fetched since intention alone might not stimulate PA as it could also (co)depend on factors such as SE, self-regulation (AP and AC), and habits (Rhodes & Yao, 2015). This is intuitive since there is also often an intention-action gap (Rhodes & Bruijn, 2013).

Table 3.

Indicators, Associated TDF, and Intervention Description

Indicator	TDF Domain	Recommended BCW IF	Intervention Description
Identity (RM)	Social/professional Role and Identity, Optimism	Incentivization	*Financial reward on good PA behaviour such as reaching a goal set in an action plan or consistent action control. *Found to be effective by Mitchell et al. (2020) and Luong et al. (2021)
Self-efficacy (RM)	Beliefs about Capability	Education	*Personalized (based on identity) physical training or instructional sessions on PA activities. *Leveraging wearables or smartphones to provide feedback to incentivize good PA behaviour. E.g. Providing persuasive notifications that elicit positive affect from individuals when a PA goal is reached.
Habits (PsC)	Behavioural Regulation	Education, Enablement	*Encouraging intended PA behaviour through haptic reminders with smartphones or wearables. *Systematic instructions or trainings on how to plan a PA goal and strategy for its execution (e.g. Implementation Intention)
Action Planning/Goal Setting (PsC)		Education, Enablement	
Action Control/Self-Monitoring (PsC)		Education, Enablement	

Intervention Theme 2: Developing Skills Behavioural Regulation

Action planning (AP) involves mapping behavioural responses to specific situations to achieve goals (Sniehotta et al., 2005). Gollwitzer's (1999) *implementation intention (II)* is a

well-known AP technique that specifies when, where, and how to act. Educating young adults about developing an AP with II can be beneficial. AP interventions have successfully promoted a healthy diet (Verplanken & Faes, 1999) and physical activity (PA) (Milne et al., 2002).

Action control (AC) and self-monitoring (SM) are interrelated concepts. AC involves effortful acts to maintain non-hedonistic behaviour with formed intentions (Sniehotta et al., 2005), while SM is awareness of one's competency. Both AC and SM require a set AP, enabling young adults to engage AC to regulate their intended PA behaviour. Interventions fostering SM (Kanfer & Karoly, 1982) and repetitive instructional training (Muraven et al., 1999) can stimulate AC. Consistent adherence to an AP through SM and AC can build associations between situational cues and intended behaviour, leading to habituation (Sniehotta et al., 2005). Integrating technology such as smartphones and wearables into interventions, through goal notifications and reminders, can enhance habit formation, action control, self-management, and monitoring, thus aiding in maintaining intended PA behaviours.

This report recommends intervention targets to develop self-management skills and improve competency-based efficacy through personalised PT sessions. Major limitations to evidence evaluation and IF recommendation include the subjective process of selecting IFs and difference in context across the studies evaluated. For example, Howlett et al.'s (2017) study was based in Australia while Willmott et al.’s (2021) was based in the UK. Recommended IFs include incentivization, education, and enablement supported by leveraging smartphones and wearables. Marketing efforts should be personalised based on individuals' exercise self-identity to encourage signing up for personalised PT sessions. Caution is advised in communication/marketing efforts, as stimuli promoting hyper-fit physiques may adversely affect PA (Gavin et al., 2006). Involvement from key stakeholders, such as the government, workplaces, or universities, is essential to facilitate private PT sessions, easing the search for dedicated providers and incentivizing PA behaviour.

To ensure not just the reach and efficacy of the recommended intervention, there should be collaboration between multiple stakeholders involved in empowering PA. For example, to allow for the adoption of PA across multiple contexts, stakeholders should enact and implement policies that support the engagement of multiple modalities of PA across different settings (WHO Report, 2022). With the wide availability of wearables, stakeholders can collaborate with the providers of these technologies to provide large datasets that could be leveraged to rapidly evaluate PA-based interventions (Moreno et al., 2021).

Conclusion

Behavioural analysis of PA with COM-B and TTM points to developing an intervention centred around providing instructional training (education) to young adults to improve competency-based self-efficacy and self-management techniques, incentivizing good PA behaviour, and enablement to facilitate SM, and encouraging young adults to reach their goals through feedback and reminders with modern technologies. Identity should be integrated into education and self-management efforts, such that goals should be created based on individuals' reported ESI. Recommended IFs are also backed by policy categories such as communication/marketing - *to create awareness and ensure instructional training sessions* - and service provision - *to ease the friction of young adults finding physical opportunities to engage in PA*.

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