Internal and External Predictors of Engaging and Adhering to Physical Activity

Pedro J. Teixeira[1], PhD; Eliana V. Carraça[1], PhD; Joreintje Mackenbach[2], PhD

It is well-known that when undertaken regularly, physical activity (PA) is highly beneficial for health, physical and cognitive functioning, and psychological wellness (Pedersen & Saltin, 2015; Sallis et al., 2016a). An active lifestyle also reduces mortality risk associated with extensive sitting time (Ekelund et al., 2016). Yet, by conservative estimates, the prevalence of inactivity among adults worldwide is 23% (Sallis et al., 2016a). A large proportion of the population report insufficient levels of physical activity to achieve or maintain good health (Eurobarometer, 2014; Hallal et al., 2012; Sallis et al., 2016a). In addition, strategies to increase physical activity vary substantially with intervention efforts typically resulting in modest effects in improving physical activity (Heath et al., 2012; Sallis et al., 2016b). Thus, understanding the factors that trigger or influence the adoption of physical activity is critical.

Engaging in and adhering to a habit of regular physical activity is complex and multidimensional. Ecological models emphasize that physical activity are influenced by an interaction of multiple factors, ranging from the personal (bio-psychological) level to the socio-economical, cultural and physical environmental level (Sallis, Owen, & Fisher, 2008). These factors can broadly be classified as internal and external (to the individual), respectively; the latter still receiving considerably less attention (Biddle & Mutrie, 2008). Different terminologies can be adopted to refer to variables related to behavioral adoption and maintenance, such as *determinants*, *correlates* or *predictors*. In this review, we will use the latter by which we mean variables that are *predictive* of behavior in either correlational models of analysis (i.e., predictive in the statistical sense) or experimental models, thus with stronger causal inference. However, this decision is largely an arbitrary choice.

Early research in the field of exercise psychology was typically concerned with the identification of significant associations between a collection of very diverse variables and exercise/physical activity, without seeking to understand whether and how these variables were

mostly derived from theoretical models (Rhodes & Nigg, 2011), particularly at the personal level (e.g., self-efficacy, intrinsic motivation, perceived barriers and benefits, intention). Integration of concepts from several theories into a socioecological model, including interrelations between individuals and their sociocultural and physical environments, is now customary (Sallis et al., 2008). Yet, although external factors such as facets of the built environment have been gaining recognition as important predictors of physical activity (Bauman et al., 2012), this integrative model still challenges researchers and practitioners due to its lack of theoretical or mechanistic underpinnings (Rhodes & Nigg, 2011).

In this chapter, a historical perspective on the most prominent internal and external factors will be presented, followed by new insights on less explored predictors both at the individual and environmental levels (e.g. identity/schema, affective factors, distance to physical features such as bicycle lanes and parks), which have the potential to add to the current understanding of the promotion of physical activity. Finally, future avenues of research will be provided along with some practical implications of this body of research.

Internal predictors of physical activity

Internal predictors of physical activity have been studied quite extensively, using two main approaches, an atheoretical approach and a theory-based approach. The first approach was broadly used in early research, which was mainly concerned with the assessment of associations between very diverse factors and physical activity. Predictors from this type of research have been organized into several categories, including demographic, biological, psychological, and behavioral, and summarized in several previous reviews (e.g., Bauman et al., 2012; Sallis et al., 2016a; Sallis & Owen, 1999; Trost, Owen, Bauman, Sallis, & Brown, 2002). We now provide a summary of those findings, largely based on review articles, which did not emphasize theoretical aspects.

Key demographic correlates of higher levels of physical activity include male gender,

al., 2002). Health status is one of the clearest correlate of physical activity in adults (Bauman et al., 2012), with individuals presenting chronic diseases and poorer levels of functional capacity being less likely to be physically active (Durstine, Gordon, Wang, & Luo, 2013). Overweight/obesity is inversely associated with physical activity levels (Bauman et al., 2012; Trost et al., 2002), and might even be a predictor of physical inactivity (e.g., Ekelund, Brage, Besson, Sharp, & Wareham, 2008). Physical activity characteristics, in particular, perceived effort, also appear to be negatively correlated with physical activity (Bauman et al., 2012). From the wide list of psychosocial measures studied thus far, self-efficacy remains the strongest and most consistent psychological correlate of physical activity (Bauman et al., 2012), despite a relative lack of experimental research to support its role as a mediator (Rhodes & Pfaeffli, 2010). Other psychological correlates include fewer perceived barriers towards physical activity, expected benefits, stronger intentions, and exercise enjoyment (Trost et al., 2002). In addition, prior reviews have found that physical activity was more likely in those using processes of behavior change according to the transtheoretical model (Bauman et al., 2012; Trost et al., 2002). Behavioral correlates that have been associated with current physical activity habits include prior (a history of) physical activity during adulthood, but not during childhood, suggesting a modest tracking of physical activity from childhood (Bauman et al., 2012; Trost et al., 2002). However, a more recent review of literature from Finland has found good tracking from early childhood to young adulthood activity levels (Telama et al., 2014). Although not all studies have shown a significant association between smoking and physical activity, most have reported an inverse association (Trost et al., 2002). There also seems to exist a relationship between the quality of dietary habits and engaging in regular physical activity, although this association has been less frequently studied (Trost et al., 2002).

One of the most recently published reviews on correlates of physical activity focused on research conducted in low and middle-income countries (Sallis et al., 2016a), as almost 75% of deaths related to non-communicable diseases occur in these countries (WHO, 2017). Results

associations with physical activity (Sallis et al., 2016a). Prior reviews have also suggested that physical activity correlates might be context and population-specific, differing, for instance, between occupational and daily-living contexts or between employed and non-employed individuals (e.g., Kaewthummanukul & Brown, 2006; Kirk & Rhodes, 2011).

Theoretical research can be a useful starting point for understanding people's behavior and could be helpful in developing more explanatory models of physical activity habits. Theories of motivation and behavior provide such a platform and theory-based research is broadly recommended (Michie, West, Campbell, Brown, & Gainforth, 2014). Theories provide a more in-depth understanding of causes of behavior including moderators and mediators of change, temporal sequences, and logical relations between different predictors. By identifying true mechanisms of action, theory-based research is especially useful to design interventions that target those mechanisms and test by which mechanisms they work, or fail to work (Michie et al., 2016). Most contemporary research on internal correlates of physical activity is, therefore, derived from theoretical models.

Current theories/models and results

The four most prominent theories in this field are the Theory of Planned Behavior, Social Cognitive Theory/Self-efficacy Theory, the Transtheoretical Model, and Self-Determination Theory. Their most relevant features are summarized below along with a summary of findings for their predictive capacity for physical activity outcomes. A brief description of each follows.

The Theory of Planned Behavior (TPB) proposes that attitudes, subjective norms, and perceived behavioral control are antecedents of intentions, which constitute the proximal predictor of physical activity behavior (Ajzen, 1991). TPB is able to explain 24 to 27% of the variance in physical activity behavior according to previous reviews (Hagger, Chatzisarantis, & Biddle, 2002; McEachan, Conner, Taylor, & Lawton, 2011). Prior meta-analytical research has found large effect sizes between intentions and physical activity, and has shown that intentions

Symons-Downs & Hausenblas, 2005). Yet, a more recent review of *mediators* of physical activity behavior was only able to find three intervention studies testing TPB, and none formally testing the mediation paths proposed by TPB, despite more than 200 correlational studies using the theory (Rhodes & Pfaeffli, 2010).

Prior research has also indicated that TPB does not account for all the variance in intention and behavior (Biddle & Mutrie, 2008). For instance, Hagger et al. (2002) found that past behavior reduced the strength of other TPB paths, suggesting that studies not assessing it could be getting artificially high correlations. Habit has also been shown to account for an additional 7 % of variance in physical activity after adjusting for intentions, supporting the hypothesis that engagement in physical activity involves both conscious and automatic components (Rhodes, de Bruijn, & Matheson, 2010).

Social Cognitive Theory (SCT) conceives behavior as the result of a complex interaction between the individual, environment, and behavior. Self-efficacy constitutes the pivotal construct of this theory, influencing the behavior directly and indirectly through the other model constructs (Bandura, 1997). Anticipatory outcome expectations is the second most important construct within SCT, and along with socio-cultural factors that might facilitate or hinder behaviors, will affect physical activity indirectly through goals/intentions and self-regulation skills (Bandura, 2004).

Overall, SCT is able to explain about one-third of the variance in physical activity (Young, Plotnikoff, Collins, Callister, & Morgan, 2014). In this meta-analytic review, self-efficacy, self-regulation skills, and behavioral intentions were consistently and positively associated with behavior, while outcome expectations and socio-structural (external) factors were not (Young et al., 2014). Specifically, 60% of the models showed a significant direct effect of self-efficacy on physical activity, while 44% showed a significant indirect effect (though only 9 of 25 studies reported these effects). The goal construct, either represented by self-regulation measures (i.e., goal setting, planning) or behavioral intentions, was directly associated with physical activity, in 70% and 86% of the studies, respectively (Young et al., 2014). This finding

highlight the relative importance of the goal construct, which has been frequently ignored in prior SCT research (Rhodes & Nigg, 2011; Young et al., 2014). Still, only 40% of the models measured all the major SCT constructs, and only 4% used valid and reliable scales (both aspects that have been shown to moderate the proportion of variance explained in physical activity; Young et al., 2014).

The Transtheoretical Model (TTM) is an integrative model proposing that behavior change involves movement through several stages (pre-contemplation, contemplation, preparation, action, maintenance, and termination), and includes multiple processes of change (i.e., cognitive/thinking and behavioral strategies), decisional balance (i.e., weighing the pros and cons of behavior change), and self-efficacy (Prochaska & DiClemente, 1982).

Generally, support has been found for most TTM correlates of stage membership: processes of change, self-efficacy, and decisional balance pros show increased levels at more advanced stages of change, whereas temptations and decisional balance cons tend to be lower in later stages of change (Spencer, Adams, Malone, Roy, & Yost, 2006). However, more recent reviews found that very few intervention studies (i.e., 29%) have been developed using all TTM constructs (Hutchison, Breckon, & Johnston, 2009), or have formally tested TTM constructs as mediators of change in physical activity behavior (i.e., 5%; Rhodes & Pfaeffli, 2010).

Taken together, these findings suggest that the efficacy of TTM-based approaches in changing physical activity cannot be accurately determined (Hutchison et al., 2009; Rhodes & Pfaeffli, 2010). Further criticisms of the TTM have been noted, on both theoretical and empirical grounds (e.g., West, 2005) suggesting that, despite its descriptive face value – any given person can be placed on a relative position from not considering change to behavioral maintenance – TTM's usefulness in intervention research and practice is very limited.

Self-Determination Theory (SDT) is a comprehensive macro-theory of human personality and motivated behavior, which advocates that the satisfaction of the basic psychological needs of autonomy, competence, and relatedness, is required for the endorsement of autonomous motivations, long-lasting behavior adherence, and increased well-being (Deci & Ryan, 2000).

according to SDT (Kasser & Ryan, 1996).

A previous systematic review highlighted the importance of more autonomous motivations in fostering physical activity (Teixeira, Carraça, Markland, Silva, & Ryan, 2012). Perceived competence and more intrinsic goals were also consistent predictors of increased physical activity across a range of samples and settings; however, most studies were cross-sectional (63%) and mainly tested the association between motivational regulations and physical activity (79%). Only a few SDT-based interventions designed to promote physical activity were identified in a review by Teixeira et al. (2012). Of these, only three employed a comprehensive set of strategies more fully embracing SDT core principles. These factors precluded the accurate testing of SDT-based interventions' efficacy. Since then, new interventions informed by SDT have been developed (e.g., Duda et al., 2014; Friederichs, Oenema, Bolman, & Lechner, 2015; Van Hoecke et al., 2013; Weman-Josefsson, Johnson, & Lindwall, 2016), generally supporting the role of autonomous motivation in physical activity adherence.

In conclusion, extensive validity testing of TPB, TTM and SDT exists, suggesting that these theories are helpful in predicting physical activity. However, as highlighted, most research on these theories relies on cross-sectional/correlational data, which prevents a definitive estimation of their usefulness in exercise / activity behavior change. More intervention studies are thus required. It is also critical that future studies test a higher number of key theory constructs to allow more precise behavioral predictions. For example, in the case of SCT, research has mainly focused on the role of self-efficacy (Rhodes & Nigg, 2011; Young et al., 2014). Finally, it would be relevant to test more parsimonious / unique models in the physical activity domain that could, for instance, eliminate those constructs that frequently show weak or insignificant associations (e.g., subjective norms in TPB) and include new and promising constructs in the prediction of physical activity (e.g., affect-related constructs [more below on this topic]).

Methodological and measurement issues

continues to be derived mostly from cross-sectional research. Despite evidence suggesting that no substantial differences in the prediction of physical activity exist between cross-sectional and experimental designs (Rhodes & Plotnikoff, 2005; Teixeira et al., 2012; Young et al., 2014), cross-sectional research needs to be complemented with more applied intervention studies that adequately model, implement, and test the key hypotheses of the theory in question. In effect, the few intervention theory-based studies that exist rarely include or test all of the theory's constructs. This is true for research using SCT (Young et al., 2014) or SDT (Teixeira et al., 2012), just to cite two theories. Clearly, more studies including more/all constructs within these theories, as well as their interactions, are needed.

The latest available review on theory-based mediators of physical activity indicated that half of the theory-based interventions reviewed (i.e., 11 of 22 interventions) were not able to effectively change participants' physical activity, nor the mediators in-between (Rhodes & Pfaeffli, 2010). Methodological study quality appears to be an important moderator of the explanatory power of theoretical models, with higher quality models explaining more variance in physical activity than lower quality models (Young et al., 2014). Poor quality studies seem to dominate research in this particular area. In addition to the reliance on cross-sectional designs, common limitations include the use of highly variable measures to assess the same construct, the use of inappropriate measures (i.e., behavior-unspecific, non-comprehensive, lacking information regarding internal consistency or test-retest reliability), non-random selection of participants, no power calculations provided, and lack of adjustment for past behavior (Teixeira et al., 2012; Young et al., 2014). McEachan et al. (2011) also noted that methodological characteristics moderated behavioral effect sizes, with behaviors assessed in the shorter term and through self-report better predicting physical activity. Heterogeneity within samples with regard to factors such as age, gender, weight or body composition, and fitness status may be contributing to variability across studies, and has been indicated as a major limitation (Teixeira et al., 2012). Moderation analyses to evaluate the influence of these factors are rarely conducted, but there may be much to learn from examining profiles that are specific to different

different patterns of motivation have been observed between long-term exercisers and beginners (Sebire, Standage, & Vansteenkiste, 2008).

In summary, more applied intervention studies that adequately test the major propositions of each theory, preferentially including all constructs within these theories and considering their interactions and causal relationships, are critical to advance research in this field. It is also important that studies with higher methodological quality (e.g., stronger designs, appropriate measures, testing moderating effects) are developed to increase our capability in predicting physical activity.

Recent and innovative research

The most popular theories in contemporary physical activity research have shown mixed success in changing health behavior (Conn, Hafdahl, & Mehr, 2011), inspiring the exploration of new alternative routes that place less emphasis on cognitive and reasoned action approaches (Rhodes & Nigg, 2011). Two areas show some promising results and have the potential to make important additions to the understanding of physical activity and complement the most prominent theories.

The affective response to physical activity – whether by anticipation of its (affective) benefits or by hedonic experiences during and after the behavior – has been postulated as an important predictor of future physical activity (Bryan, Hutchison, Seals, & Allen, 2007; Williams, 2008). Key motivational mediators include affective attitude, self-efficacy, and intention to be physically active (Rhodes, Fiala, & Conner, 2009; Williams & Evans, 2014).

In 2013, Ekkekakis and colleagues reviewed and summarized the role of affect in exercise behaviors, describing it as "the driving factor of physical activity motivation" (Ekkekakis, Hargreaves, & Parfitt, 2013), paving the way for research exploring dual-system models of decision-making, which include both reflective and affective components. A more recent systematic review indicated that positive changes in the basic (pleasure/displeasure) affective response to moderate intensity exercise was associated with future physical activity and

predictive of future physical activity compared to more proximal consequences (i.e., affective response during exercise). This review further evaluated how the affective response to physical activity related to major potential mediators of behavior, showing negligible relations with intention, mixed findings for self-efficacy, and reliable medium-sized associations with affective appraisals about future physical activity (i.e., enjoyment, intrinsic motivation, affective attitude). These findings support the basic premise of hedonic theories of behavior (Johnston, 2003), suggesting that affective experiences during exercise might have an important role on sustained behavior adoption. Formal mediation analyses and practical application studies are warranted to confirm and extend current research on this topic.

Another construct that may improve current understanding of physical activity is identity. Generally, identity refers to self-referenced mental representations and associated thoughts and feelings we have in a given role; in other words, how we think and feel about ourselves in that particular role (Burke, 2006). In relation to exercise/physical activity, one can think of individuals who describe themselves as 'athletes', as 'runners' or as 'commuter bikers'; examples of people in whom we might expect identity-related aspects featuring high in their motivation to be physically active. Because of its convergence with the construct of self-schema (see Rhodes, Kaushal, & Quinlan, 2016), identity and schema will be considered together herein.

Identity/schema is thought to be linked to intention and subsequent behavior through wider personal and sociocultural contexts, while the constructs from the most prominent behavior change theories tend to be within-behavior specific (Rise, Sheeran, & Hukkelberg, 2010). Identity/schema is also thought to represent a maintenance rather than an adoption-based concept, given that it is likely shaped long after initial physical activity intentions and behavior have occurred. Its role in translating intentions into behavior may therefore be especially relevant (Rhodes & Yao, 2015). Moreover, it may constitute a central source of automatic motivation (Williams & Evans, 2014), given that its mechanisms are believed to be both reflexive and context-activated (Stets & Burke, 2000), which set them apart from most contemporary theories/constructs of exercise motivation, largely cognitive and individually-focused. Self-

explicitly refers to motives which are deeply "internalized" (i.e. congruent with one's identity and values; Deci & Ryan, 2000).

A recent meta-analytic review confirmed most of these hypotheses (Rhodes et al., 2016): self-schema/identity was identified as a strong correlate of physical activity behavior, paralleling the associations observed between intentions and behavior in the literature (Bauman et al., 2012). Consistent with previous research (Rise et al., 2010), self-schema/identity was found to be a reliable predictor of intentions to be physically active, even after adjusting for social cognitive constructs (Rhodes et al., 2016). It was also found to moderate the intention-behavior association, further supporting its potential to reduce the intention-behavior gap (Rhodes & Yao, 2015). Likewise, schema/identity was a consistent predictor of self-regulation strategies and self-regulation efficacy, suggesting that it may be linked to the use of volitional strategies that have been shown to be closely related to successful physical activity behavior change (Rhodes & Pfaeffli, 2010). Still, available evidence is too scarce and mostly correlational; hence, these findings need to be interpreted with caution, and confirmed in future experimental research (Rhodes et al., 2016).

External predictors of Physical Activity

Next to internal (individual-level) predictors, external (environmental-level) predictors of physical activity are also of importance in understanding exercise behavior. These predictors can be defined as the broader 'context' in which physical activity takes place, and include, among other factors, physical activities of peers, the activity-friendliness of the home neighborhood, and policies that stimulate active travel. External predictors, such as environmental influences, are not well understood, but potentially constitute the most modifiable class of influences that should be targeted through public health interventions aimed at increasing population levels of physical activity (Owen, Leslie, Salmon, & Fotheringham, 2000). Indeed, environments can act as barriers to or facilitators of physical activity and environmental modifications may have a large impact on the physical activity levels of whole groups.

A number of theories emphasize the importance of external predictors of physical activity. Behavioral Choice Theory proposes that both internal processes and external processes, and their interactions, influence behavioral choices (Rachlin, 1989). SCT, on the other hand, stresses that self-efficacy influences physical activity via goal setting and outcome expectations, but also via socio-cultural factors such as social support and perceived environment. SCT proposes that behavior is a function of constant reciprocal interaction between personal and environmental factors (Bandura, 1997).

Young and colleagues (2014) summarized the literature investigating the use of SCT to explain physical activity, and found that the pathways from self-efficacy to physical activity via socio-structural factors were found to be very inconsistent, with only 16% of the associations between perceived environment and physical activity reported as significant. This may partly be explained because SCT is mainly used for explaining challenging or novel behaviors (Lox, Martin-Ginis, & Petruzzello, 2006) – thereby being potentially less influential for engaging in habitual physical activities.

'Social ecological' models recognize the influence of the broader context in which behavioral choices are made (Green, Richard, & Potvin, 1996; Sallis et al., 2008). Sallis et al. (2008) developed the 'Ecological Model for Four Domains of Active Living', identifying factors at the intrapersonal level, the perceived environment, wider behavior settings, and the policy environment that influence active recreation, active transport, household activities and occupational activities (Sallis et al., 2006). The environment (e.g., perceived environment, behavior settings, policy environment) can be classified into different types of environments. The *physical environment* refers to 'what is available', including opportunities for participation in leisure, occupational or incidental activity, such as the availability of cycle paths, accessible stairs in buildings and availability of sports grounds (Swinburn, Egger, & Raza, 1999). The physical environment is sometimes divided into the 'built' and the 'natural' environment, distinguishing between man-made (e.g., cycle paths) and natural (e.g., beaches) environmental features.

between the physical environment and physical activity have been published, whether focused on walking (e.g., Saelens & Handy, 2008), active travel (e.g., Cerin, Nathan, Van Cauwenberg, Barnett, & Barnett, 2017), or other forms of physical activity (e.g., McCormack & Shiell, 2011). In addition, one literature review studied the relation between the home physical environment and physical activity (Kaushal & Rhodes, 2014), and one review described the evidence for social environmental influences on physical activity (McNeill, Kreuter, & Subramanian, 2006). Most of the primary studies included in these literature reviews were observational, cross-sectional studies, providing a modest body of evidence for environmental determinants of physical activity.

These reviews, a reflection of prior empirical research, showed that the availability, accessibility and convenience of destinations and facilities, as well as the general functionality of the neighborhood were positively associated with various levels of physical activity (McCormack et al., 2004; McCormack & Shiell, 2011). Malambo and colleagues found that residential density, safety from traffic, recreational facilities, street connectivity and high walkable environment were associated with physical activity (Malambo, Kengne, De Villiers, Lambert, & Puoane, 2016). Factors consistently associated with domains of physical activity were walkability (including street connectivity and residential density), access to facilities and destinations, compact development patterns, and overall functionality of the neighborhood (including dedicated cycling routes/paths). Less consistent evidence is found for proximity to parks and recreation areas, aesthetic features, perceptions about traffic and busy roads and feelings of safety. Overall, environmental attributes seem to be more important for active travel (i.e., transport-related physical activity) than for leisure time physical activity (Ewing, 2005; McCormack & Shiell, 2011; Saelens & Handy, 2008; Van Holle et al., 2012), and the evidence is somewhat stronger for older populations who may be more dependent on their neighborhood environment (Cerin et al., 2017; Moran, Van Cauwenberg, Hercky-Linnewiel, Cerin, & Deforche, 2014; Van Cauwenberg et al., 2011). Most studies, however, were conducted in urban environments only, and are unlikely representative of rural areas, which might comprise unique

In addition, the importance of environmental features may depend on the broader context. Alfonzo describes the 'hierarchy of walking needs', suggesting that there are various 'levels' of environmental conditions that can be met. First, walking needs to be feasible. Second, the environment and its destinations need to be accessible. Third, the environment needs to be safe. Fourth, the environment should be comfortable for walking. Fifth, the environment should be pleasurable (Alfonzo, 2005). This may be true for other physical activities as well. For example, in areas where there are no cycling paths (i.e., lack of feasibility), pleasurability (e.g., aesthetics) may not be associated with cycling, whereas in areas where cycling is feasible and safe, and destinations are accessible, comfort and pleasurability may start to play a more important role. For instance, a recent study conducted across 14 cities worldwide showed that residential density, intersection density, public transport density, and number of parks were four factors consistently associated with physical activity (Sallis et al., 2016b), suggesting that there is a basic set of urban design features (i.e., cities built for car use or for active transportation) that may stimulate several forms of physical activity.

For the home environment, there is limited evidence for an association with physical activity (Kaushal & Rhodes, 2014). This may be because most moderate-to-vigorous physical activities are conducted outside the home, and the home environment may mainly influence *in*activity and sedentary behaviors (O'Donoghue et al., 2016).

More recent studies have focused on whether environmental changes (i.e., experiments) can actually influence the physical activity levels of communities and populations (Benton, Anderson, Hunter, & French, 2016; Hunter et al., 2015; Martin, Ogilvie, & Suhrcke, 2014; Mayne, Auchinclos, & Michael, 2015). Martin and colleagues concluded that natural experiments do not necessarily provide more consistent evidence for an association between the physical environment and physical activity (Martin et al., 2014). However Benton and colleagues suggest that the limited evidence from natural experiments does indicate that changes in the built environmental may lead to increases in physical activity levels. However, they also note that effect sizes are generally more modest than in single cross-sectional studies, and that many

Natural experiments generally showed stronger results when the intervention involved improvements to active transportation infrastructure, and when investigating specific behavior settings (e.g., relation between cycling infrastructure and cycling, rather than total physical activity) (Mayne et al., 2015). This is in line with observational studies that suggest that there are stronger links of compact development patterns with active travel than overall physical activity (Ewing, 2005) and with the suggestion of Ding and Gebel (2012) to take into account the conceptual match between environmental attributes and domains of physical activity. Other researchers also emphasize the importance of context-specificity in their model of potential influences of 'behavior settings', referring to those social and physical contexts in which behaviors take place (Owen et al., 2000). Concordantly, urban planning theories often make specific links between the 'transportation system' and transport-related physical activity (Handy, Boarnet, Ewing, & Killingsworth, 2002). Socio-ecological models also describe the role of *socio-cultural*, *economic* and *political environments* for physical activity.

Social and cultural norms can have powerful effects on individuals and communities, ranging from healthy role models for students at the micro-level to mass media campaigns at the macro-level. For example, social support from peers seems to be an important correlate of physical activity (Trost et al., 2002), especially in older (Chogahara, Cousins, & Wankel, 1998) and younger (Treiber et al., 1991; Zhang et al., 2016) adults. Social support is often delivered via social networks of friends, family, colleagues, and neighbors, among others. Social networks provide access to resources and material goods and enable (or constrain) the adoption of health-promoting behaviors (McNeill et al., 2006). The concepts of 'social cohesion' and 'social capital' (the extent of connectedness and solidarity among groups; McNeill et al., 2006) may affect physical activity levels via the ability to enforce social norms for positive health behaviors. The few studies conducted to date, however, provide mixed evidence for this hypothesis (Ball et al., 2010; Lindstrom & Ostergren, 2003; Mackenbach et al., 2016b; Ueshima et al., 2010).

Economic environmental influences of physical activity include micro-level factors such as family budgets for sport club memberships as well as macro-level factors such as budgets

barrier for participating in sports activities, especially in those with lower incomes (Steenhuis, Nooy, Moes, & Schuit, 2009).

Finally, the political level refers to the rules and regulations, ranging from family rules about time spent in front of the television at the micro-level to town planning policies at the macro-level (Swinburn et al., 1999). Policies can affect physical activity in many ways; e.g., through improving access to opportunities for physical activity, through regulating the quantity and quality of physical education, through promoting programs and national campaigns to stimulate physical activity, etc. Yet, relatively little empirical evidence is available indicating a need for formal evaluations of physical activity policies.

Methodological and measurement issues

Next to limitations associated with the measurement of physical activities, associations with external predictors also depend on the methods and measures used to operationalize environmental constructs. Objective environmental data is usually obtained from field audits, which involve observers with checklists documenting specific aspects of the built environment, or geocoded data in Geographic Information Systems (GIS). GIS are systems designed to capture, store, analyze and present spatial (geographic) data and use geographic coordinates or other spatial data to determine the location of environmental features of interest (Charreire et al., 2014).

Regardless of the way the data are collected, researchers make assumptions with regard to individuals' 'exposure' to the physical environment. Specific exposures in the physical environment can rarely be studied in isolation, and single environmental components often make only a small contribution to total physical activity levels. In addition, it is difficult to define the 'boundaries' of relevant areas: Is having destinations within 500 meters from home more relevant than having destinations within a 5-kilometer distance?

Recent studies have demonstrated that the effects of physical environmental characteristics on physical activity differ between studies that used 'pre-defined' boundaries

2001; Zenk et al., 2011). Some studies use Global Positioning Systems (GPS) to measure where individuals go during a regular day or week, such as obtaining objective data on individuals' activity spaces. Instead of objectively measuring 'what is available', participants can also be asked to report on their neighborhood *perceptions* through surveys or interviews. However, previous studies have shown that there is a discordance between objective and perceived neighborhood characteristics (Roda et al., 2016). In addition, less active individuals may adjust their beliefs and perceptions with regard to their neighborhood environment to match their actions, also referred to as 'same-source bias', or 'cognitive dissonance bias' (Festinger, 1957).

Cross-sectional studies (and longitudinal studies too, to some extent) may suffer from self-selection bias, which limits the interpretation of the extent to which environment-behavior associations can be attributed to the environment, and the extent to which they should be attributed to socio-demographic or attitudinal factors (Moktahrian & Cao, 2008). That is, any association between green space and physical activity may be the result of physically active individuals 'self-selecting' themselves into neighborhoods where they can act upon their preferences for physical activity. The latter is a form of direct self-selection, while indirect forms of self-selection include self-selection by socioeconomic status. In some areas, less physically active people also have fewer means to live in a nice, activity-conducing neighborhood.

Residential self-selection becomes a problem when selection factors are not appropriately controlled for. Three studies accounted for residential self-selection, and concluded that it attenuated the association between built environment characteristics and physical activity (McCormack & Shiell, 2011). Although there is still debate about the method to account for self-selection variables, and what kind of variables should be taken into account, there seems to be consensus that self-selection plays at least some role in explaining associations between the built environment and physical activity (Bohte, Maat, & van Wee, 2009; Boone-Heinonen, Gordon-Larsen, Guilkey, Jacobs Jr., & Popkin, 2011; Cao, Mokhtarian, & Handy, 2009; Mokhtarian & Cao, 2008; Næss, 2009; Søgaard, Selmer, Bjertness, & Thelle, 2004).

Systems perspectives on the determinants of physical activity and health recognize that the behavior of individuals and populations are always a manifestation of broad systems in which biological, psychological and environmental factors influence each other in complex, dynamic ways that may change over time. This is important for understanding life course processes, place effects and the impact of upstream policies (Diez Roux, 2011). Although both social ecological models and systems science propose complex interactions between multiple determinants, they are rarely tested in empirical studies. One study showed that self-efficacy, social influence and positive attitude were more strongly associated with sports participation in adults who perceived their neighborhood as unsafe than adults who perceived their neighborhood to be safe (Beenackers, Kamphuis, Burdorf, Mackenbach, & van Lenthe, 2011; Beenackers, Kamphuis, Mackenbach, Burdorf, & van Lenthe, 2013). Another study showed that the absence of parks, bicycle lanes, indoor and outdoor recreational facilities was more strongly related in those who perceived many barriers to be physically active than those who perceived no barriers to be physically active (Mackenbach et al., 2016a). A third study showed that higher social diversity in the neighborhood was only associated with more transport walking in a "highly-walkable" neighborhoods (Van Holle et al., 2016).

An innovative way to improve the measurement of 'exposure' to the built environment is the use of smartphone-based Ecological Momentary Assessments (EMA) (Dunton, 2017; Liao, Intille, & Dunton, 2015; Schlicht, Ebner-Priemer, & Kanning, 2013). EMA methods take advantage of recent advancements in mobile and sensor technologies to get insights into the complexities of physical activities; it is a real-time self-report strategy that helps describe the physical and social contexts of physical activity. EMA helps better understand where, with whom, why, and how much physical activity occurs. However, it also requires specialized hard- and software, and the resulting longitudinal data needs sophisticated statistical analyses, which may be one reason why this type of measurement has not often been used. The study by Liao and colleagues demonstrated that most physical activities occurred when participants were alone; that women were more physically active in outdoor home locations (e.g., yard), whereas men where

New directions in future research

In the last few decades, various behavioral theories and models have been used to guide the selection of variables in interventions. However, there is no one theory created specifically within the domain of physical activity to encourage a more active lifestyle, especially to adopt an exercise habit. Whether or not a specific theory will emerge (e.g., Rhodes & Nigg, 2011), physical activity share a number of features that are distinguishable from other health behaviors (e.g., those related to physical ability or fitness) and we should expect this specificity to be further considered in future adherence work. It is also very likely that future research on determinants and predictive models progressively considers specificities *within* physical activity. For instance, as highlighted in this chapter, active travel, recreational running, brisk walking, and participation in sports, among others, may be explained by considerably different sets of factors. However, it is often the case that measures of physical activity used in research include these behaviors in broad categories (e.g. "leisure-time" activity), a fact which most certainly limits the value and power of explanatory models.

One other direction, which has been explored in recent years, is the potential for the *integration* or "merging" of multiple theories to help explain, describe, or predict a more active lifestyle. One example is the Integrated Behavior-Change (IBC) Model for Physical Activity (Hagger & Chatzisarantis, 2014), which combines features from the Theory of Planned Behavior and Self-Determination Theory. As another response to the proliferation of theories of behavior (Michie et al., 2014), experts have proposed the use of broad and overarching models, such as the COM-B model (Michie, Stralen, & West, 2011), that together encompass the most important categories of behavior determinants (in this case Competence, Opportunity, and Motivation). Advantages and limitations of such initiatives have been addressed elsewhere (Teixeira, 2016), and extend beyond the scope of this chapter. A short summary is that while parsimony and practical utility are benefited by efforts to synthetize and isolate key determinants from the most popular models, researchers need to be watchful about the underlying (meta-theoretical)

detail / nuance is not lost in the process, as it can be critical for the most accurate design of interventions.

Most studies have used cross-sectional designs, providing evidence of associations instead of causal, mechanistic relations between factors and physical activity (Bauman et al., 2012). Moving to experimental or longitudinal analysis of behavior change research is critical, as this allows the testing of theory application, theory propositions and causal relations between constructs, their capability of change, and the existence of mediation effects supporting physical activity changes.

Relatively few intervention studies have shown effective changes in outcome behaviors and hypothesized mediators, or included formal tests of mediation (Rhodes & Pfaeffli, 2010). Employing more sophisticated methods to test mediators of physical activity, which test the significance of the indirect effect (e.g., Structural Equation Modeling procedures, Preacher and Hayes procedures), along with improved measures of exposure factors (i.e., comprehensive, uniform within the same construct) and objective physical activity measures, is also of relevance for understanding which factors predict exercise behavior.

Finally, we should expect future research to be increasingly devoted to the issue of behavioral maintenance, also called adherence (Amireault , Godin, & Vézina-Im, 2013). In part as a consequence of changes in health care models that now prioritize prevention and the *long-term* management of non-communicable diseases, but also because of widespread evidence that relapse is normative in lifestyle behavioral modification (e.g., Muller-Riemenschneider, Reinhold, Nocon, & Willich, 2008), theoretical and empirical review studies that specifically address behavioral maintenance have blossomed in the last decade (e.g., Amireault et al., 2013; Kwasnicka, Dombrowski, White, & Sniehotta, 2016; Nigg, Borrelli, Maddock, & Dishman, 2008; Teixeira et al., 2015). Overall, these reports indicate that physical activity research with longer-term outcomes is still lacking and warrants continued attention; that variables in the domains of motivation, confidence and self-efficacy, and self-regulation skills (e.g. goal setting, self-monitoring, and action planning/control), which have received most theoretical and

cues and incentives, etc.) should progressively be integrated in multilevel, socioecological, predictive models of maintained behavior.

Practical considerations and applications

While teaching future health professionals or when communicating to educators, practitioners, and scholars already working in the field, we have often found the COM-B model (Michie et al., 2011) of great utility to address the topic of theories and determinants of physical activity. Students and especially practitioners often find it difficult to deal with a multitude of theories and variables they should consider as an integral part of their work. The three categories of Competence, Opportunity, and Motivation do a fairly good job of framing the most important issues or factors professionals need to know when working with clients and patients. The COM-B model also sets the stage to address the role of mediators, i.e., to convey the concept that there are specific mechanisms health professionals should target in their practice (not target behavior directly) which largely determine the efficacy of their interventions. We will use the COM-B model here to highlight some practical applications derived from this chapter, addressing both internal and external predictors.

With respect to *competence*, this category includes variables related to confidence in one's ability to carry out an exercise/activity program (e.g., for health and fitness reasons; Bandura, 1997), as well as motives related to skill development and *feeling* competent and masterful while carrying out an activity or because of it (Deci & Ryan, 2000). Both aspects are supported in the literature, the former typically under the label of self-efficacy, the latter as perceived competence. Regarding self-efficacy for physical activity, a 2010 review study found that giving feedback on past or others' performance, and also techniques that promoted vicarious experiences (e.g., watching others succeeding) were associated with the highest increases in self-efficacy (Ashford, Edmunds, & French, 2010). By contrast, this systematic review and meta-analysis suggested that using verbal persuasion graded mastery techniques (e.g., progressively increasing the difficulty of the target behavior), and identifying barriers were not effective

achievement) were also useful techniques for promoting confidence and efficacy (Williams & French, 2011). These results notwithstanding, the fact that self-reports of self-efficacy in research studies are probably confounded by how motivated a person is for the behavior. (Williams & Rhodes, 2016) suggest that practitioners should not look at increasing confidence in isolation from *motivational* aspects. We now turn to those.

In their 2016 review on maintenance of health behaviors, Kwasnicka and colleagues explain why considering motives is paramount for behavior change (Kwasnicka et al., 2016). They write that "people tend to maintain their behaviour if they are satisfied with behavioural outcomes, they enjoy engaging in the behaviour; and if behaviour is congruent with their identity, beliefs, and values" (Kwasnicka et al., 2016, p. 7). This is a good summary of the findings reported in this chapter from theories such as the Theory of Planned Behavior (Hagger et al., 2002; McEachan et al., 2011) and Self-determination Theory (Teixeira et al., 2012), paving the way to practical techniques that promote optimal motivation through these mechanisms, especially positive attitudes and adequate outcome expectations, and intrinsic/autonomous motivation. Considering that most practitioners are typically proactive in talking to clients about the benefits of, and what to expect from physical activity (i.e., attitudes, expected benefits), we will focus here on how to foster internal and personally relevant (i.e., autonomous) forms of motivation. Indeed, this is an area where we have found training of health professionals to be lacking.

Self-determination theory, described before, suggests a number of practical techniques to ensure practitioners nurture more internal motives in clients, as opposed to reasons focused on external contingencies and pressures (Patrick & Williams, 2012). Key aspects of "autonomy-promoting" practice include: eliciting clients/patients' views on, and discussing meaningful rationales for behavior/behavior change; giving options (e.g. about physical activities and ways to experiment them) and providing a sense of choice; adopting a neutral, non-controlling language (e.g., avoiding constraining, directive, or guilt-inducing language); and creating an empathetic and collaborative relational climate (Silva, Marques, & Teixeira, 2014). Interestingly,

showed that exercise professionals who felt more pressured in their jobs adopted more controlling strategies towards their clients and reported higher levels of emotional exhaustion (Silva et al., 2017).

Finally, in the COM-B model, *opportunity* refers to social and physical factors that either predispose and facilitate or, conversely, create barriers to behavior change. It is not always the case that contextual conditions can be changed as a consequence of a practitioner's intervention. However, just being mindful that the adoption or maintenance of physical activity by a patient/client is not determined merely by his/her willingness and ability – but also by powerful environmental forces that either encourage or impede behavior change – is one major step for professionals. All too commonly, patients and clients are encouraged, by society and practitioners alike, to believe that adopting a healthier lifestyle is an easy and simple matter, and equally accessible to all. Taken as a whole, research on predictors of physical activity described in this chapter suggests otherwise and recommends that practitioners stay informed on external influences of developing healthy habits, particularly in reference to exercise and other forms of physical activity, to maximize their chances of success with their clients and patients.

Conclusions

This chapter provides an update on internal and external factors that influence physical activity that have been identified by research in the last few decades. Throughout this text, we have identified key predictors of adoption and/or maintenance of physical activity and briefly described some new directions in the most current research alongside methodological considerations. Finally, we have attempted to translate these findings in practical ways for those working with clients and patients. Because physical activity represents a very diverse set of behaviors enacted in a complex and ever-changing environment, there are no simple answers as to what predicts physical activity at levels sufficient to affect health and well-being. Indeed, health and well-being is only one of the reasons to be physically active, and one which has, perhaps, been overemphasized (e.g., Segar, Guérin, Phillips, & Fortier, 2016). For many people,

nature) or are contingent on mundane purposes such as serving as a way of transportation or as part of a job or occupation.

This broad landscape for physical activity challenges researchers to capture invariant predictors of behavior and creates abundant avenues for intervention research – which will be increasingly behavior-specific – creating a problem for those trying to synthesize research findings. Conversely, for practitioners and also for public health officials tasked with promoting physical activity behavior change (in individuals, groups, and populations), this scenario presents numerous possibilities for interventions and policies that can make a difference in the real world (Reis et al., 2016).

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