Mental Health and Physical Activity 18 (2020) 100315

Contents lists available at ScienceDirect

Mental Health and Physical Activity

journal homepage: www.elsevier.com/locate/menpa

Do we need physical activity guidelines for mental health: What does the evidence tell us?

Megan Teychenne[a,*], Rhiannon L. White[b], Justin Richards[c,d], Felipe B. Schuch[e], Simon Rosenbaum[f,g], Jason A. Bennie[h]

[a] Deakin University, Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences, Geelong, Australia
[b] School of Science and Health, Western Sydney University, Locked Bag 1797, Penrith NSW, 2751, Australia
[c] School of Public Health & Charles Perkins Centre, University of Sydney, Australia
[d] Faculty of Health, Victoria University of Wellington, Wellington, New Zealand
[e] Department of Sports Methods and Techniques, Federal University of Santa Maria, Santa Maria, Brazil
[f] School of Psychiatry, Faculty of Medicine, UNSW, Sydney, Australia
[g] Black Dog Institute, Sydney, Australia
[h] Physically Active Lifestyles Research Group (USQ PALs), Centre for Health, Informatics, And Economics Research, Institute for Resilient Regions University of Southern Queensland, Australia

ARTICLE INFO

Keywords:
Depression
Exercise
Mental health
Mental illness
Physical activity
Prevention

ABSTRACT

The aims of this commentary are to (1) examine the current global physical activity recommendations for adults and its relation to mental health, based on findings from meta-analyses primarily of prospective studies, and (2) determine whether there is a need to extend the scope/focus of existing guidelines to ensure they are mental health informed.

Poor mental health and well-being is a major cause of disease burden globally, with depression considered a leading contributor (Vigo, Thornicroft, & Atun, 2016). Physical activity is well recognised as a key risk factor for the prevention and management of mental ill-being, including, but not limited to, mental disorders such as depression, anxiety and post-traumatic stress disorder (PTSD). Since the late 1970's, physical activity for health guidelines have been developed and refined over several decades by leading international experts in the field (Oja & Titze, 2011). Broadly, the purpose of physical activity guidelines is to provide recommendations to improve overall health and well-being. Originally, the physical activity guidelines were proposed for preventing cardiovascular disease-related mortality, and, subsequently, were developed to encompass other prevalent chronic conditions (e.g. cancer, diabetes) (U.S Department of Health and Human Services, 2018). Currently, the global recommendations are based on reducing the risk of common chronic/non-communicable diseases (NCD's), relating specifically to cardiorespiratory health, metabolic health, musculoskeletal health, cancer, functional health and *depression* (World Health Organisation, 2010).

Physical activity recommendations for public health describe the type (e.g. aerobic, strength) and dose (e.g. duration, frequency, intensity and/or volume) of physical activity required by adults to reduce the likelihood of developing NCD's. However, given that evidence has shown that the relationship between physical activity and mental health/ill-health is likely to, in part, be influenced by contextual factors across the lifespan (e.g. domain of physical activity, autonomous participation), there may be need to extend the focus/scope of existing physical activity guidelines to ensure they effectively address mental health (Richards, Doherty, & Foster, 2015; Teychenne, Ball, & Salmon, 2010; White et al., 2017). This paper examines the current global physical activity recommendations for adults (World Health Organisation, 2010) and its relation to mental health, with a key focus on depression.

* Corresponding author. Deakin University, Geelong, Australia, Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences, Melbourne Burwood Campus, 221 Burwood Hwy, Burwood, VIC, 3125, Australia.
E-mail addresses: mteych@deakin.edu.au (M. Teychenne), Rhiannon.White@westernsydney.edu.au (R.L. White), justin.richards@sydney.edu.au (J. Richards), felipe.schuch@ufsm.br (F.B. Schuch), s.rosenbaum@unsw.edu.au (S. Rosenbaum), Jason.Bennie@usq.edu.au (J.A. Bennie).

https://doi.org/10.1016/j.mhpa.2019.100315
Received 12 August 2019; Received in revised form 11 November 2019; Accepted 11 November 2019
Available online 15 November 2019
1755-2966/

1. The global physical activity for health recommendations

1.1. Dose

The global physical activity for health recommendations suggest adults should participate in 150 min/week of moderate-intensity aerobic physical activity, or 75 min/week of vigorous-intensity aerobic physical activity, or an equivalent combination of both. Additional health benefits are also suggested at higher volumes (i.e. 300 min/week of moderate-intensity aerobic physical activity, or 150 min/week of vigorous-intensity aerobic physical activity, or an equivalent combination of both) (World Health Organisation, 2010). In line with the global recommendations, a recent meta-analysis of prospective cohort studies demonstrated in sub-group analyses that completing 150 min/week of moderate-vigorous physical activity was protective against developing depression, reducing the risk by about 22% (Schuch et al., 2018). Although that study was unable to determine the 'optimal dose' of physical activity for the prevention of depression, due to the small number of existing studies that include comprehensive and/or comparable dosage information, it was concluded that higher levels of physical activity were associated with lower risk of developing depression (Schuch et al., 2018). Further, systematic reviews have shown that even low doses (e.g. < 150 min per week of light-, or moderate-intensity) of physical activity are associated with a reduced likelihood of depression (Mammen & Faulkner, 2013; Teychenne, Ball, & Salmon, 2008). Therefore, it may be important to acknowledge that mental health benefits may be obtainable at lower doses, particularly since those experiencing and/or at greatest risk of mental ill-health are more likely to be physically inactive (Hiles, Lamers, Milaneschi, & Penninx, 2017; Schuch et al., 2017; Vancampfort et al., 2017), and prefer physical activity of a light-to moderate-intensity (Fraser, Chapman, Brown, Whiteford, & Burton, 2015). This recommendation is concordant to the current U.S and Australian guidelines that suggest "doing any physical activity is better than doing none" (Brown, Bauman, Bull, & Burton, 2012; U.S Department of Health and Human Services, 2018).

It is acknowledged that there are likely multiple dose-response curves for various health outcomes (Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010). Therefore, we are not suggesting that guidelines be developed for every conceivable health outcome, as that would likely create confusion in public health messaging. Rather, given that more than a quarter of the global population do not meet current aerobic guidelines (Guthold, Stevens, Riley, & Bull, 2018), and those most at risk of poor mental (and physical) health are amongst the least active (Hiles et al., 2017), it is important that guidelines are perceived as achievable by those who are currently inactive. This has been argued previously whereby a critical review of existing guidelines in Canada showed evidence that lower levels of physical activity (i.e. half the volume of current guidelines) likely led to marked health benefits (Warburton & Bredin, 2016).

1.1.1. What about the bouts?

In line with the current global physical activity recommendations (World Health Organisation, 2010), in 2018 the US Physical Activity guidelines were updated in which the historic recommendation of needing to accumulate physical activity in at least 10-min continuous bouts was removed (U.S Department of Health and Human Services, 2018). This was in light of evidence suggesting that any bouts (short or long) can be beneficial for health (Piercy et al., 2018). Although most research has investigated the association between total volume of weekly physical activity and subsequent depression (Schuch et al., 2018), a small body of evidence from systematic reviews of RCT's has shown that short bouts of physical activity (e.g. 10–15 min) can reduce stress, depressive symptoms and improve self-esteem in adults (Barr-Anderson, AuYoung, Whitt-Glover, Glenn, & Yancey, 2011). Despite being unable to determine an optimal minimal duration of bout length, a recent controlled randomised crossover trial conducted among 32 adults showed that 3 bouts of stair climbing for 1-min each resulted in increased positive mood state (feeling energetic) and decreased negative mood state (feeling tense and tired) immediately after the brief intervention (Stenling, Moylan, Fulton, & Machado, 2019). However, further research utilising large-scale prospective designs is warranted to investigate the effect of short bouts of objectively measured physical activity on mental health.

1.1.2. What about HIIT?

High intensity interval training (HIIT) has received much attention in recent years as a viable way of achieving maximum health benefits in minimal time. While HIIT aligns with the recommendations around vigorous intensity physical activity, and may certainly lead to physical benefits above and beyond moderate physical activity, there is currently limited research examines the effect of HIIT on mental health outcomes. Initial experimental studies suggest that HIIT may lead to improvements in psychological wellbeing among adolescents (Costigan, Eather, Plotnikoff, Hillman, & Lubans, 2016) and improvements in mental health for people with chronic schizophrenia (Wu, Lee, Hsu, Chang, & Chen, 2015). However, some evidence suggests that HITT interventions may have no significant effect on anxiety or perceived stress in young adults (Eather et al., 2019). While there is no evidence to suggest that HIIT is detrimental to mental health, it is important to note that these interventions have compared HIIT to a control group but have not compared HITT to other types of physical activity. As such, mental health benefits derived through participation in HIIT may not specifically be due to the high intensity or the interval training component, but merely, the participation in some form of physical activity. Additionally, high intensity exercise may be associated with more negative affective states during participation, compared to lower-intensity exercise, which can predict drop-out and therefore reduce the likelihood of meeting physical activity guidelines (Biddle & Batterham, 2015). The strenuous nature of HIIT may also undermine competence (Biddle & Batterham, 2015), particularly for those who are inactive. This is important to note as perceived competence not only predicts sustained participation in physical activity (Biddle & Mutrie, 2007), but is also associated with increased positive affect and reduced negative affect (Teixeira, Marques, & Palmeira, 2018).

1.2. Type

In addition to aerobic physical activity, the global recommendations suggest engaging in two or more days per week of muscle-strengthening activities involving major muscle groups (World Health Organisation, 2010). Most prospective studies investigating whether physical activity can prevent future depressive symptoms have not distinguished between the type (i.e. mode) of physical activity (Mammen & Faulkner, 2013; Schuch et al., 2018). However, there is meta-analytical evidence from randomised controlled trials to suggest that both modalities (i.e. muscle-strengthening (Gordon et al., 2018) and aerobic (Schuch et al., 2016)) exercise results in reduced depressive symptoms. In those meta-analyses, when comparing aerobic exercise only and muscle strengthening exercise only, there was no significant difference between these physical activity modalities in reducing depressive symptoms. Further, there is emerging evidence that suggests that adults adhering to both the aerobic (i.e. moderate-vigorous physical activity) and muscle-strengthening activities guidelines have the lowest likelihood of depressive symptoms, compared to those who adhere to only one guideline (either aerobic or muscle-strengthening activities) (Bennie, Teychenne, De Cocker, & Biddle, 2019). Thus, on balance, it appears that by including both aerobic and muscle-strengthening physical activities, the current global guidelines are likely to enhance the protective effect of physical activity for mental health. However, there is still need for further prospective research to investigate the association between muscle-strengthening activities and mental health outcomes to draw firm conclusions on the effectiveness of this mode of physical

activity for preventing poor mental health.

1.3. Life domain

The global physical activity recommendations state that for adults "physical activity includes recreational or leisure-time physical activity, transportation (e.g. walking or cycling), occupational (i.e. work), household chores, play, games, sports or planned exercise, in the context of daily, family, and community activities". In essence, the guidelines encourage adults to be physically active during any life domain. Indeed, for physical health including cardiorespiratory health, metabolic health, musculoskeletal health, cancer prevention, and functional health, the domain of physical activity is likely to be irrelevant, and rather the dose and/or type (mode) may be most important. However, for the prevention of mental ill-health and the promotion of positive mental health, the domain of physical activity plays a significant role. In fact, the role of life domain is so influential that physical activity may have completely opposite effects on mental ill-health depending on the context in which it is undertaken. Meta-analytical evidence shows that leisure-time and transport-related physical activity are each positively associated with mental health, with leisure-time physical activity also inversely associated with mental ill-health (White et al., 2017). Conversely, work-related physical activity was positively associated with mental ill-health, while household (i.e. domestic) physical activity was not associated with mental health or ill-health (White et al., 2017). These domain-specific differences in mental health outcomes can be explained by a number of potential underlying mechanisms (see following section). Thus, we propose that future guidelines explicitly recommend that, where possible, some weekly physical activity be undertaken for leisure or transport purposes in order to increase the likelihood of mental health benefits.

1.3.1. Psychosocial mechanisms and contextual factors

While physiological mechanisms (e.g., stimulation of neuroplastic processes, reduction of inflammation, increases in resilience to physiological stress) (Kandola, Ashdown-Franks, Hendrikse, Sabiston, & Stubbs, 2019) play a role in the effect of physical activity on mental health, domain-specific differences in the association with mental health suggests that the association between physical activity and mental health is not purely because of physiological mechanisms. Therefore, other aspects of the physical activity experience need to be considered. Factors such as enjoyment, mastery of skills/goals, autonomous motivation, choice, social interaction, and a sense of belonging (Biddle & Mutrie, 2007; White et al., 2018b) likely influence the relationship between physical activity and mental health. Yet these factors are more likely to be present when undertaking physical activity for leisure or transport purposes, rather than for domestic/household or work purposes (Teychenne, Abbott, Lamb, Rosenbaum, & Ball, 2017). For example, emerging evidence suggests that physical activity that is enjoyable or personally important and chosen to be undertaken (i.e. autonomously motivated) is associated with positive affect, while physical activity undertaken due to guilt, pressure, or feeling forced (i.e. controlled motivation) is associated with negative affect (White et al., 2018b). Leisure-time physical activity is likely the most autonomously endorsed physical activity domain, and active travel may or may not be autonomously endorsed; however, work-related and household physical activity are unlikely to offer the same level of enjoyment. Further, household and work-related physical activity may not provide a distraction from stress or provide opportunities for mastery, social interaction, or improved self-esteem.

Qualitative evidence also suggests that aspects of the physical activity experience such as music and nature can influence the association between physical activity and wellbeing (Wright, Armstrong, Taylor, & Dean, 2012), meaning the quality of the physical activity experience may be particularly essential to the mental health outcomes obtained (Lambert et al., 2018). Studies have shown that exposure to greenspace is associated with lower levels of depression, anxiety, and stress (Beyer et al., 2014; Cohen-Cline, Turkheimer, & Duncan, 2015) and that physical activity outdoors is associated with greater reductions in depression and anxiety, than physical activity indoors (Thompson Coon et al., 2011). More recently, blue space (e.g., oceans) has been associated with higher wellbeing (Garrett et al., 2019), further suggesting that nature may be important. However, studies have not examined whether physical activity in blue space is more beneficial than physical activity without exposure to nature. Similar to connecting with nature, connecting with other people during physical activity may be important. However, evidence around the role of social interaction in the physical activity – mental health relationship is preliminary (Kandola et al., 2019) and further research is needed to examine whether physical activity with others is more beneficial than physical activity alone. Nevertheless, it is also important to consider the quality of relationships in future research, as a sense of belonging may foster improved mood and wellbeing more than simply being in the same room or fitness class as another person (White, Olson, Parker, Astell-Burt, & Lonsdale, 2018a). While the satisfaction of autonomy (i.e., "the need to self-regulate one's experiences and actions") (Ryan & Deci, 2017) is essential to promoting autonomous motivation and as a consequence the likelihood of meeting the recommended amount of physical activity (Teixeira, Carraca, Markland, Silva, & Ryan, 2012), autonomy-supportive physical activity experiences may also be more likely to improve mood and positive affect compared to activities where individuals have no choice or where the activity does not align with their interests (Gagne, 2003; Puente & Anshel, 2010; Wilson, Longley, Muon, Rodgers, & Murray, 2006). As such, interventions have now been centred on the satisfaction of autonomy, competence, and relatedness to improve physical activity adherence and wellbeing among people with poor mental health (Lambert, Greaves, Farrand, Haase, & Taylor, 2017). Indeed, physical activity guidelines could encourage individuals to participate in activities that they enjoy or that are personally meaningful.

1.4. Sedentary behaviour

The global physical activity recommendations for health do not currently discuss sedentary behaviour. However, physical activity guidelines from countries such as the U.S and Australia recommend, "sitting less" (U.S Department of Health and Human Services, 2018) or "minimising the time spent in prolonged sitting" (Brown et al., 2012). Although meta-analytical evidence has shown that the relative risk of developing depression/depressive symptoms was higher amongst those who engage in higher levels of sedentary behaviour, this was based on just 11 prospective studies (Zhai, Zhang, & Zhang, 2015). Recent evidence from a small experimental study utilising Ecological Momentary Assessment suggests that sedentary behaviour may adversely affect mood independent of physical activity (Giurgiu et al., 2019). It is, however, likely that the association between sedentary behaviour and mental health is specific to the type of sedentary behaviour (e.g. TV viewing is likely to have different associations with mental health compared to computer use, or electronic device use) (Teychenne et al., 2010; Teychenne & Hinkley, 2016) and as such, type of sedentary behaviour should be considered when synthesising the evidence in regards to mental health outcomes. Given that further prospective research investigating whether sedentary behaviour predicts depressive symptoms is needed, we conclude that it would be premature to include a sedentary behaviour guideline for mental health purposes.

1.5. Other mental health outcomes

Currently the predominant mental illness referred to in the global physical activity for health recommendations is *depression* (World Health Organisation, 2010). That is likely since the majority of studies investigating the link between physical activity and mental health have examined depression. However, it is now well established that physical

activity plays a role in both the promotion of *mental well-being* and prevention of *mental ill-being*, including and beyond that of diagnosed disorders such as depression, anxiety, substance use disorders, PTSD and schizophrenia. For example, meta-analytical evidence has shown that physical activity is associated with reduced risk of incident anxiety (Schuch et al., 2019), as well as better general mental health (White et al., 2017). Despite global physical activity guidelines focusing on depression, many national physical activity guidelines (e.g., Australian and Canadian) state that benefits of achieving the recommended physical activity include the development and maintenance of mental health and well-being (Canadian Society for Exercise Physiology, 2011; Department of Health and Ageing, 2010). Given that individuals can experience poor mental health without a clinically diagnosable mental health disorder, global physical activity guidelines should consider targeting mental health and well-being in addition to reducing the overall burden of mental illness (e.g. depression, anxiety, PTSD, schizophrenia).

2. Conclusions

This paper examined the current global physical activity recommendations for adults in relation to mental health. While acknowledging that current guidelines are based on a comprehensive review of the literature, our review suggests that although the 'optimal dose' is uncertain, the physical activity-mental health relationship is apparent even at low doses, but is domain specific. Based on our review, we propose that global recommendations: 1) consider both the prevention of mental ill-being and the promotion of mental well-being. Further, we propose global recommendations include the following two points: 2) do some of your physical activity during leisure-time or in active travel, where possible prioritising activities you enjoy or personally choose to undertake; and 3) some physical activity is better than none for both physical and mental health. Guidelines that promote physical activity during any life domain understandably lead to public health campaigns encouraging people to simply *"move more"* by engaging in incidental physical activity behaviours. This messaging may increase physical activity but, may not lead to improved mental health or reduced mental ill-health (e.g., depression). Instead, if individuals are encouraged to participate in small amounts of enjoyable physical activity, ideally during leisure-time, the likelihood of receiving mental health benefits alongside physical benefits may increase. Thus, physical activity would then truly play a role in mental health promotion that is equal in magnitude to its potential.

Funding

SR is funded by an NHMRC Early Career fellowship APP1123336. FBS is funded by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Code 001. The sponsors had no such involvement in any aspect of the manuscript preparation, or the decision to publish.

Declaration of competing interest

None.

References

Barr-Anderson, D. J., AuYoung, M., Whitt-Glover, M. C., Glenn, B. A., & Yancey, A. K. (2011). Integration of short bouts of physical activity into organizational routine: A systematic review of the literature. *American Journal of Preventive Medicine, 40*, 76–93.

Bennie, J. A., Teychenne, M. J., De Cocker, K., & Biddle, S. J. H. (2019). Associations between aerobic and muscle-strengthening exercise with depressive symptom severity among 17,839 U.S. adults. *Preventive Medicine, 121*, 121–127.

Beyer, K. M., Kaltenbach, A., Szabo, A., Bogar, S., Nieto, F. J., & Malecki, K. M. (2014). Exposure to neighborhood green space and mental health: Evidence from the survey of the health of Wisconsin. *International Journal of Environmental Research and Public Health, 11*, 3453–3472.

Biddle, S. J., & Batterham, A. M. (2015). High-intensity interval exercise training for public health: A big HIT or shall we HIT it on the head? *International Journal of Behavioral Nutrition and Physical Activity, 12*, 95.

Biddle, S. J., & Mutrie, N. (2007). *Psychology of physical activity: Determinants, well-being and interventions.* Routledge.

Brown, W. J., Bauman, A. E., Bull, F. C., & Burton, N. W. (2012). *Development of evidence-based physical activity recommendations for adults (18-64 years.* Australian Government Department of Health.

Canadian Society for Exercise Physiology (2011). *Physical activity tips for adults (18-64 years).* Ontario: Public Health Agency of Canada.

Cohen-Cline, H., Turkheimer, E., & Duncan, G. E. (2015). Access to green space, physical activity and mental health: A twin study. *Journal of Epidemiology & Community Health, 69*, 523–529.

Costigan, S. A., Eather, N., Plotnikoff, R. C., Hillman, C. H., & Lubans, D. R. (2016). High-intensity interval training for cognitive and mental health in adolescents. *Medicine & Science in Sports & Exercise, 48*, 1985–1993.

Department of Health and Ageing (2010). *An active way to better health: National physical activity guidelines for adults.* Canberra: Department of Health and Ageing.

Eather, N., Riley, N., Miller, A., Smith, V., Poole, A., Vincze, L., et al. (2019). Efficacy and feasibility of HIIT training for university students: The Uni-HIIT RCT. *Journal of Science and Medicine in Sport, 22*, 596–601.

Fraser, S. J., Chapman, J. J., Brown, W. J., Whiteford, H. A., & Burton, N. W. (2015). Physical activity attitudes and preferences among inpatient adults with mental illness. *International Journal of Mental Health Nursing, 24*, 413–420.

Gagne, M. (2003). Autonomy support and need satisfaction in the motivation and well-being of gymnasts. *Journal of Applied Sport Psychology, 15*, 372–390.

Garrett, J. K., White, M. P., Huang, J., Ng, S., Hui, Z., Leung, C., et al. (2019). Urban blue space and health and wellbeing in Hong Kong: Results from a survey of older adults. *Health & Place, 55*, 100–110.

Giurgiu, M., Koch, E. D., Ottenbacher, J., Plotnikoff, R. C., Ebner-Priemer, U. W., & Reichert, M. (2019). Sedentary behavior in everyday life relates negatively to mood: An ambulatory assessment study. *Scandinavian Journal of Medicine & Science in Sports, 29*(9), 1340–1351.

Gordon, B. R., McDowell, C. P., Hallgren, M., Meyer, J. D., Lyons, M., & Herring, M. P. (2018). Association of efficacy of resistance exercise training with depressive symptoms: Meta-analysis and meta-regression analysis of randomized clinical trials. *JAMA Psychiatry, 75*, 566–576.

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2018). Worldwide trends in insufficient physical activity from 2001 to 2016: A pooled analysis of 358 population-based surveys with 1.9 million participants. *Lancet Glob Health, 6*, e1077–e1086.

Hiles, S. A., Lamers, F., Milaneschi, Y., & Penninx, B. (2017). Sit, step, sweat: Longitudinal associations between physical activity patterns, anxiety and depression. *Psychological Medicine, 47*, 1466–1477.

Kandola, A., Ashdown-Franks, G., Hendrikse, J., Sabiston, C. M., & Stubbs, B. (2019). Physical activity and depression: Towards understanding the antidepressant mechanisms of physical activity. *Neuroscience & Biobehavioral Reviews, 107*, 525–539.

Lambert, J. D., Greaves, C. J., Farrand, P., Haase, A. M., & Taylor, A. H. (2017). Development of a web-based intervention (eMotion) based on behavioural activation to promote physical activity in people with depression. *Mental Health and Physical Activity, 13*, 120–136.

Lambert, J. D., Greaves, C. J., Farrand, P., Price, L., Haase, A. M., & Taylor, A. H. (2018). Web-based intervention using behavioral activation and physical activity for adults with depression (the eMotion study): Pilot randomized controlled trial. *Journal of Medical Internet Research, 20*, e10112.

Mammen, G., & Faulkner, G. (2013). Physical activity and the prevention of depression: A systematic review of prospective studies. *American Journal of Preventive Medicine, 45*, 649–657.

Oja, P., & Titze, S. (2011). Physical activity recommendations for public health: Development and policy context. *The EPMA Journal, 2*, 253–259.

Piercy, K. L., Troiano, R. P., Ballard, R. M., Carlson, S. A., Fulton, J. E., Galuska, D. A., et al. (2018). The physical activity guidelines for Americans. *Journal of the American Medical Association, 320*, 2020–2028.

Puente, R., & Anshel, M. H. (2010). Exercisers' perceptions of their fitness instructor's interacting style, perceived competence, and autonomy as a function of self-determined regulation to exercise, enjoyment, affect, and exercise frequency. *Scandinavian Journal of Psychology, 51*, 38–45.

Richards, J., Doherty, A., & Foster, C. (2015). Is the current focus of the global physical activity recommendations for youth appropriate in all settings? *Journal of Physical Activity and Health, 12*, 901–903.

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness.* Guilford Publications.

Schuch, F. B., Stubbs, B., Meyer, J., Heissel, A., Zech, P., Vancampfort, D., et al. (2019). *Physical activity protects from incident anxiety: A meta-analysis of prospective cohort studies.* Depress Anxietyhttps://doi.org/10.1002/da.22915.

Schuch, F., Vancampfort, D., Firth, J., Rosenbaum, S., Ward, P., Reichert, T., et al. (2017). Physical activity and sedentary behavior in people with major depressive disorder: A systematic review and meta-analysis. *Journal of Affective Disorders, 210*, 139–150.

Schuch, F. B., Vancampfort, D., Firth, J., Rosenbaum, S., Ward, P. B., Silva, E. S., et al. (2018). Physical activity and incident depression: A meta-analysis of prospective cohort studies. *American Journal of Psychiatry, 175*, 631–648.

Schuch, F. B., Vancampfort, D., Richards, J., Rosenbaum, S., Ward, P. B., & Stubbs, B. (2016). Exercise as a treatment for depression: A meta-analysis adjusting for publication bias. *Journal of Psychiatric Research, 77*, 42–51.

Stenling, A., Moylan, A., Fulton, E., & Machado, L. (2019). Effects of a brief stair-climbing intervention on cognitive performance and mood states in healthy young adults.

Journal Frontiers in Psychology, 10, 2300.
Teixeira, P. J., Carraca, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 9*, 78.
Teixeira, D. S., Marques, M., & Palmeira, A. L. (2018). Associations between affect, basic psychological needs and motivation in physical activity contexts: Systematic review and meta-analysis. *Journal Revista iberoamericana de psicología del ejercicio y el deporte, 13*, 225–233.
Teychenne, M., Abbott, G., Lamb, K. E., Rosenbaum, S., & Ball, K. (2017). Is the link between movement and mental health a two-way street? Prospective associations between physical activity, sedentary behaviour and depressive symptoms among women living in socioeconomically disadvantaged neighbourhoods. *Preventive Medicine, 102*, 72–78.
Teychenne, M., Ball, K., & Salmon, J. (2008). Physical activity and likelihood of depression in adults: A review. *Preventive Medicine, 46*, 397–411.
Teychenne, M., Ball, K., & Salmon, J. (2010). Physical activity, sedentary behavior and depression among disadvantaged women. *Health Education Research, 25*, 632–644.
Teychenne, M., & Hinkley, T. (2016). Associations between screen-based sedentary behaviour and anxiety symptoms in mothers with young children. *PLoS One, 11*, e0155696.
Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., & Depledge, M. H. (2011). Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Environmental Science and Technology, 45*, 1761–1772.
U.S Department of Health and Human Services. (2018). *Physical activity guidelines for Americans* (2nd ed.). Washington, DC: Department of Health and Human Services.
Vancampfort, D., Firth, J., Schuch, F. B., Rosenbaum, S., Mugisha, J., Hallgren, M., et al. (2017). Sedentary behavior and physical activity levels in people with schizophrenia, bipolar disorder and major depressive disorder: A global systematic review and meta-analysis. *World Psychiatry, 16*, 308–315.
Vigo, D., Thornicroft, G., & Atun, R. (2016). Estimating the true global burden of mental illness. *The Lancet Psychiatry, 3*, 171–178.
Warburton, D. E., & Bredin, S. S. (2016). Reflections on physical activity and health: What should we recommend? *Canadian Journal of Cardiology, 32*, 495–504.
Warburton, D. E., Charlesworth, S., Ivey, A., Nettlefold, L., & Bredin, S. S. (2010). A systematic review of the evidence for Canada's Physical Activity Guidelines for Adults. *International Journal of Behavioral Nutrition and Physical Activity, 7*, 39.
White, R. L., Babic, M. J., Parker, P. D., Lubans, D. R., Astell-Burt, T., & Lonsdale, C. (2017). Domain-specific physical activity and mental health: A meta-analysis. *American Journal of Preventive Medicine, 52*, 653–666.
White, R. L., Olson, R., Parker, P. D., Astell-Burt, T., & Lonsdale, C. (2018a). A qualitative investigation of the perceived influence of adolescents' motivation on relationships between domain-specific physical activity and positive and negative affect. *Mental Health and Physical Activity, 14*, 113–120.
White, R. L., Parker, P. D., Lubans, D. R., MacMillan, F., Olson, R., Astell-Burt, T., et al. (2018b). Domain-specific physical activity and affective wellbeing among adolescents: An observational study of the moderating roles of autonomous and controlled motivation. *International Journal of Behavioral Nutrition and Physical Activity, 15*, 87.
Wilson, P. M., Longley, K., Muon, S., Rodgers, W. M., & Murray, T. C. (2006). Examining the contributions of perceived psychological need satisfaction to well-being in exercise 1. *Journal of Applied Biobehavioral Research, 11*, 243–264.
World Health Organisation (2010). *Global recommendations on physical activity for health.* Geneva: World Health Organisation.
Wright, K., Armstrong, T., Taylor, A., & Dean, S. (2012). 'It's a double edged sword': A qualitative analysis of the experiences of exercise amongst people with bipolar disorder. *Journal of Affective Disorders, 136*, 634–642.
Wu, M. H., Lee, C. P., Hsu, S. C., Chang, C. M., & Chen, C. Y. (2015). Effectiveness of high-intensity interval training on the mental and physical health of people with chronic schizophrenia. *Neuropsychiatric Disease and Treatment, 11*, 1255–1263.
Zhai, L., Zhang, Y., & Zhang, D. (2015). Sedentary behaviour and the risk of depression: A meta-analysis. *British Journal of Sports Medicine, 49*, 705–709.