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FULL PAPER

The influence of presumed social media influence: A longitudinal analysis of social media influence on adolescents' physical activity

Der Einfluss des vermuteten Einflusses sozialer Medien: Eine Längsschnittanalyse des Einflusses sozialer Medien auf die körperliche Aktivität von Jugendlichen

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Abstract: Social media plays a central role in adolescents' lives, suggesting powerful direct and indirect influences on their social norms and behaviors. This study examines these influences by applying the influence of presumed media influence (IPMI) hypotheses to social media and physical activity. Physical inactivity is a pressing public health concern, particularly during adolescence, when activity levels often decline. Using data from a three-wave panel survey (N = 1,044), this study analyzes the development of perceived social media exposure among peers, peer influence, social norms, and personal behavior over time. The findings reveal that social media exposure directly increases physical activity, but also via indirect effects proposed by IPMI assumptions. Perceived peer exposure and presumed influence on others strengthened injunctive social norms, resulting in higher physical activity. No significant effects were found for descriptive social norms, showing that it is important to distinguish between injunctive and descriptive norms. Theoretical and methodological implications for future research and public health interventions are discussed.

Keywords: Influence of presumed media influence, indirect media effects, social media, social norms, adolescents

Zusammenfassung: Soziale Medien spielen eine zentrale Rolle im Leben Jugendlicher und haben einen starken direkten und indirekten Einfluss auf ihre sozialen Normen und Verhaltensweisen. Die vorliegende Studie untersucht diese Einflüsse, indem sie die Hypothese des „Einflusses des vermuteten Medieneinflusses" (Influence of Presumed Media Influence, IPMI) auf soziale Medien und Sport anwendet. Körperliche Inaktivität ist ein akutes Problem für die öffentliche Gesundheit, insbesondere im Jugendalter, weil dann das Aktivitätsniveau oft sinkt. Durch eine dreiwellige Panelerhebung (N = 1.044) analysiert diese Studie die Entwicklung der Nutzung sozialer Medien, den Einfluss auf Gleichaltrige, soziale Normen und Verhalten im Laufe der Zeit. Die Ergebnisse zeigen, dass die Nutzung sozialer Medien die körperliche Aktivität direkt erhöht und den wahrgenommenen Einfluss auf Gleichaltrige und den vermuteten Einfluss auf andere steigert, was mit den IPMI-Hypothesen übereinstimmt. Der vermutete Einfluss stärkte die injunktiven sozialen Normen, was wiederum körperliche Aktivität beeinflusste. Für deskriptive soziale Normen wurden jedoch keine signifikanten Effekte gefunden. Theoretische und methodologische Implikationen für zukünftige Forschung und Interventionen im Bereich der öffentlichen Gesundheit werden diskutiert.

Schlagwörter: Einfluss des vermuteten Medieneinflusses, indirekte Medieneffekte, soziale Medien, soziale Normen, Jugendliche

1. Introduction

Physical inactivity is a leading public health issue (Strain et al., 2024) and a major cause of mortality and disability in developed countries (World Health Organization, 2024). While physical activity fluctuates across the lifespan, adolescence is a crucial period as it is an essential phase for establishing healthy behaviors (Aira et al., 2021). During this influential phase, adolescents are particularly susceptible to peer influences (Maxwell, 2002) and are among the heavy users of social media (Külling-Knecht et al., 2024). Social media has been recognized as a potentially powerful tool for promoting physical activity. The WHO (World Health Organization, 2018, p. 63) highlights social media in its global action plan as a platform for increasing physical activity. Physical-activity-related content is ubiquitous on visual social media such as Instagram (Vandenbosch et al., 2022, p. 1), where users encounter workout videos, fitspiration posts, and fitness influencers sharing their routines (Sokolova & Perez, 2021). Based on social learning theory (Bandura, 1986), such exposure can encourage adolescents to emulate physically active role models. Among other mechanisms, the effect of physical activity on social media on adolescents' physical activity can be attributed to the impact of social media content on perceived social norms, which, in turn, influence attitudes and behaviors (Gunther et al., 2006). However, the processes by which social media influence perceived norms remain underexplored. One explanation for these indirect media effects is the influence of presumed media influence (IPMI; Gunther et al., 2006; Gunther & Storey, 2003).

The IPMI hypotheses posit a stepwise indirect effect of media content on behavior, applied to physical activity as follows. First, individuals are exposed to media content referencing physical activity. Second, they infer others' exposure to the same physical activity content based on their own exposure. Third, they assume that these others are influenced by this physical activity content. Fourth, this assumed influence on others shapes individual's perceptions of descriptive and injunctive social norms regarding physical activity. Descriptive norms are based on perceptions of others' behaviors, while injunctive norms are based on perceptions of others' attitudes (Lapinski & Rimal, 2005). Fifth, these perceived social norms serve as a foundation for behavioral reactions, for example, by adapting their physical activity behavior (Gunther et al., 2006).

The IPMI hypotheses have been broadly applied in media research, particularly in health-related contexts, including adolescents' tobacco use (Cho et al., 2021; Wang & Jiang, 2017), body image and body satisfaction (Chia & Wen, 2010; Park, 2005), healthy diets (Ho et al., 2016; Hong & Kim, 2020), and alcohol consumption (Davis et al., 2019; Ho et al., 2014). Few studies have applied the IPMI framework to physical activity (Ho et al., 2016), despite its critical public health importance, especially among adolescents. Ho et al. (2016) demonstrated that, for adults, perceived peer exposure and perceived peer influence of media content promoting healthy lifestyles influenced their intentions to exercise and follow a healthy diet (Ho et al., 2016, p. 1076). However, they analyzed the IPMI hypotheses in the context of traditional mass media, specifically "print newspaper, television, and outdoor media" (Ho et al., 2016, p. 1075).

To build on this research, we propose two adaptations. First, we apply the IPMI to adolescents. The World Health Organization (2025, first paragraph) defines adolescence as the period between 10 and 19, while this study focuses on late adolescents aged 14–18 (Patton et al., 2016, p. 2425). Social norms are especially relevant during adolescence (Steinberg & Monahan, 2007), physical activity typically declines during adolescence (Aira et al., 2021), and adolescents are among the heavy users of social media (Külling-Knecht et al., 2024). As a result, they are exposed to significant amounts of physical activity content on visual platforms such as Instagram (Durau et al., 2024).

Second, given the prevalence of social media use among adolescents, we will examine the influence of exposure to physical activity content on social media, more specifically on Instagram, which has been popular among adolescents in recent years (Gonzalez, 2023, second chapter). Physical activity is especially prevalent on the visual platform Instagram, with fitness influencers sharing workout plans and promoting active lifestyles (Pretorius et al., 2022; Sokolova & Perez, 2021). Thus, we apply the IPMI hypotheses to Instagram and adolescents with the overarching hypothesis that *exposure to physical activity content on Instagram increases adolescents' physical activity directly and indirectly through increased perceived peer exposure, presumed influence on others, and perceived social norms.*

Most IPMI research assumes a causal relationship between media use, perceived social norms, and behavior. This relationship has primarily been examined through cross-sectional surveys (e.g., Gunther et al., 2006, p. 56; Ho et al., 2016, p. 1075). Longitudinal data are necessary to clarify the causal relationships among media exposure, perceived peer exposure, presumed influence on others, and physical activity. Although the need for longitudinal studies has been highlighted in IPMI research (e.g., Bernhard & Dohle, 2018, p. 464; Cheng & Chen, 2020, p. 723), only a few studies have addressed this gap in topics such as smoking (Paek et al., 2011), pornography, or sugar consumption (Tal-Or et al., 2010). The mixed results of these studies underscore the importance of examining the interplay between media exposure, assumed peer exposure and peer influence, perceived social norms, and behavior over time. This study employed a three-wave panel survey to analyze the development of IPMI over time.

2. Theoretical background

2.1 Social media exposure and physical activity

Social media is integral to adolescents' daily lives and serves as a powerful tool for influencing their levels of physical activity (Dunlop et al., 2016, p. 44). While several studies have examined the general effects of social media use on physical activity (e.g., Rutter et al., 2021; Shimoga et al., 2019), few have investigated how specific content influences users' physical activity. However, studies highlight the relevance of the specific content consumed on social media as influential on attitudes and beliefs rather than the mere time spent on the platform (Sanzari et al., 2023, p. 6).

The topic of physical activity is ubiquitous on visual social media such as Instagram (Vandenbosch et al., 2022, p. 1). Based on social learning theory (Bandura, 1986), it can be argued that observing others engage in physical activity may lead to modeling. Consequently, adolescents often exposed to people engaging in physical activity on social media should also engage in more physical activity. Users' exposure to physical activity content can be actively sought (e.g., by looking for a workout routine) or can happen passively (e.g., by scrolling through the feed) (Goodyear, Boardley, Chiou, Fenton, Makopoulou, Stathi, Wallis, Veldhuijzen van Zanten, & Thompson, 2021, p. 6). Physical activity on Instagram is multifaceted: Examples include "fitspiration" posts promoting healthy lifestyles, including workout videos, fitness influencers sharing their routines, athletes sharing insights into training sessions, friends posting about their workout routines or their most recent soccer games (Durau et al., 2024; Sokolova & Perez, 2021). Understanding the influence of physical activity content on Instagram on its users' physical activity requires examining their exposure to such content.

Empirical studies focused on the possible influence of physical activity on social media on adolescents' real-life physical activity. A meta-analysis, for instance, showed that social media interventions promoting physical activity successfully increase users' actual physical activity (Günther et al., 2021, p. 9). Followers of health and fitness channels on social media exhibited no differences in physical activity compared to non-followers (Folk & Kovacs, 2021, p. 107). Nevertheless, specific types of content, such as workout posts or fitness videos, can motivate diverse groups of users – including fitness technology users (Johns et al., 2017), inactive individuals (Goodyear, Boardley, Chiou, Fenton, Makopoulou, Stathi, Wallis, Veldhuijzen van Zanten, Wood, et al., 2021), active individuals (Sokolova & Perez, 2021), people with a body mass index over 25 (Santtila et al., 2014), and general social media users (Greyling & Naud, 2023) – to engage in physical activity. Empirical findings also support the influence of physical activity content on real-life physical activity. Based on this theoretical and empirical support, we propose the following hypothesis:

> *H1: Media exposure to physical activity content on social media increases adolescents' physical activity.*

2.2 Media exposure and presumed peer exposure

Following the IPMI hypotheses, it is not only the direct effect of media content on media users that influences their behavior but also the presumed media exposure of others. The theoretical assumptions are that individuals use their own exposure to social media to estimate their peers' exposure to the same content by means of a heuristic (Tversky & Kahneman, 1971, p. 105) or a false consensus effect (Mullen et al., 1985, p. 262). Applied to the context of physical activity on social media, the IPMI assumptions would be that individuals exposed to physical activity-related content on social media assume that their peers are similarly exposed to similar amounts and types of content. Research showed that individuals' exposure to a specific context increased their perceived peer exposure to such context (e.g., Cho

et al., 2021, p. 426; Gunther & Storey, 2003, p. 207; Wang & Jiang, 2017, p. 126). The same influence was also shown for physical activity media content and individuals' perceived peer exposure to physical activity in mass media (Ho et al., 2016, p. 1076). Thus, we propose the following hypothesis:

> *H2: Media exposure to physical activity content on social media increases adolescents' perceived peer exposure to such content.*

2.3 Presumed media influence on others

In addition to the hypothesized effect on presumed peer exposure, the IPMI hypotheses posit that perceived peer exposure influences peers' actual behavior. This assumption is rooted in the third-person effect framework, which shows that individuals tend to believe that others are more strongly influenced by persuasive media messages than they are themselves (Davison, 1983, p. 3). The IPMI emphasizes the presumed media influence on others as a driver of attitudes and behaviors, regardless of perceived personal impact (Gunther et al., 2006, p. 53). The IPMI hypotheses assume that individuals' perception of how much physical activity content their peers encounter on social media influences their perception of how strongly their peers are influenced by such content (Gunther, 1998, p. 490).

> *H3: Adolescents' perceived peer exposure to physical activity content on social media increases their perceived influence of such content on others' physical activity.*

2.4 The role of social norms

The perceived influence of media content on others shapes individuals' perceptions of social norms about the same topic (Gunther et al., 2006, p. 53). Social norms are understood as unwritten behavioral codes within society. Through social interactions, norms are socially negotiated and established (Chung & Rimal, 2016, p. 3), subsequently influencing behaviors in two ways. First, according to social learning theory, individuals observe their social environment to identify prevalent and acceptable behaviors within their group (Bandura, 1986). Motivated by social conformity, individuals are often willing to adopt others' opinions to fit in and gain social approval (Cialdini et al., 1990, p. 1025). Second, social norms enable people to efficiently recognize socially accepted behaviors (Jacobson et al., 2015, p. 724). Together, these processes shape perceptions of social norms and influence attitudes and behaviors (Rimal & Real, 2005, p. 410). Consequently, social norms play a crucial role in health-related behaviors.

At the individual level, two types of social norms – descriptive and injunctive – must be differentiated (Rimal & Real, 2005, p. 391). Both are closely tied to specific reference groups (Cialdini et al., 1990, p. 1015f). Descriptive norms describe how common a particular behavior is within a social group, whereas injunctive norms reflect how strongly the group approves of that behavior (Lapinski & Rimal, 2005, p. 130; Rimal & Lapinski, 2015, p. 397). Descriptive norms are based on

perceptions of others' behaviors, while injunctive norms are based on perceptions of others' attitudes (Lapinski & Rimal, 2005, p. 130). In other words, descriptive norms encompass people's beliefs about what social group members typically do. For example, if adolescents believe that their peers frequently exercise, this descriptive norm may influence their own exercise behavior. Conversely, injunctive norms encompass beliefs about what behaviors peers approve of, such as the belief that peers endorse regular exercise (Rimal & Lapinski, 2015, p. 397f).

During adolescence, individuals are particularly susceptible to social norms due to the general high relevance of social feedback (Cialdini et al., 1990, p. 1015; Steinberg & Monahan, 2007, p. 1533). In the context of health behaviors such as being physically active, adolescents are particularly susceptible to peer influences (Prinstein et al., 2001; Steinberg & Monahan, 2007, p. 1541). Adolescence is a crucial phase characterized by psychological and physical development (Maxwell, 2002). In this phase, adolescents' perception of peer norms around health behaviors are often more powerful than individual or parental attitudes (Prinstein et al., 2001), underlining the relevance of social norms for adolescents in this context of social media, peers, and physical activity.

Following the IPMI hypotheses, the perceived influence of physical activity content on others implies a change in the attitudes and behaviors of others and influences individuals' descriptive and injunctive social norms regarding physical activity (Ho et al., 2016, p. 1077). Based on social learning theory (Bandura, 1986) and social conformity (Cialdini et al., 1990), individuals form a belief about how prevalent physical activity is within their social group (descriptive norms) and how strongly their group approves of regular physical activity (injunctive norms). Accordingly, we propose the following hypothesis:

> *H4: Adolescents' perceived influence of physical activity content on social media on others' physical activity increases their (a) perceived descriptive social norms and (b) perceived injunctive social norms regarding physical activity.*

2.5 The influence of social norms on physical activity

Descriptive and injunctive social norms are relevant to health behavior. From a theoretical perspective, the Theory of Normative Social Behavior (Rimal & Real, 2005) posits that perceived social norms generally influence individual behavior. Beliefs about what others typically do (descriptive norms) affect people's behavior, partly depending on the perceptions of what others approve (injunctive norms). In the context of health behaviors, both types of social norms have been shown to influence various health-related behaviors. This is, for example, demonstrated in empirical IPMI studies, on health topics such as smoking (Gunther et al., 2006), following a healthy diet (Robinson et al., 2016), and having safer sex intentions (Hong & Kim, 2020). In the context of physical activity, descriptive norms have been less frequently studied than in areas such as drinking or environmentally conscious behaviors (Priebe & Spink, 2012, p. 284f). Meanwhile, injunctive social norms have frequently been analyzed in physical activity research, for example, in

relation to the Theory of Planned Behavior (Kim et al., 2019). For adolescents, social norms have proven to be very influential for their physical activity (Fitzgerald et al., 2012, p. 953).

In these empirical studies, both types of social norms have been shown to influence people's physical activity. First, descriptive norms are an essential predictor of physical activity (Ball et al., 2010, p. 5; Priebe & Spink, 2011, p. 96). Among athletes, perceived descriptive norms predict their effort during practices and games (Spink et al., 2013, p. 815). Additionally, descriptive norm messages are more effective in increasing physical activity than other message types, such as those promoting health or appearance (Priebe & Spink, 2012, p. 289). Second, injunctive social norms also influence physical activity. For example, according to the theory of planned behavior, injunctive norms significantly affect physical activity (Blue et al., 2001, p. 491; Kim et al., 2019, p. 37). General research on physical activity has shown that injunctive norms increase activity levels across diverse groups, including adolescents (Abraído-Lanza et al., 2017, p. 291; Lu et al., 2014, p. 368). Building on the Theory of Normative Social Behavior (Rimal & Real, 2005) and the empirical findings outlined above, we hypothesize the following:

> *H5: Adolescents' (a) perceived descriptive social norms and (b) perceived injunctive social norms regarding physical activity increase their physical activity.*

2.6 Media influence, peer exposure, and physical activity development over time

Despite the causal assumptions in the IPMI hypotheses regarding media exposure, perceived peer exposure and peer influence, and attitudes or behaviors, many IPMI studies rely on cross-sectional data. A two-wave panel study showed that relationships between IPMI variables can be overinterpreted without longitudinal designs. For instance, presumed peer exposure (T1) did not influence perceived peer influence (T2), nor did perceived peer influence (T1) affect people's attitudes (T2). At the same time, peer exposure was positively related to peer influence and attitudes (Dohle et al., 2017, p. 605f). Cross-sectional studies cannot test causal relationships, underscoring the importance of analyzing temporal interplay with longitudinal data (e.g., Bernhard & Dohle, 2018, p. 463; Cheng & Chen, 2020, p. 723).

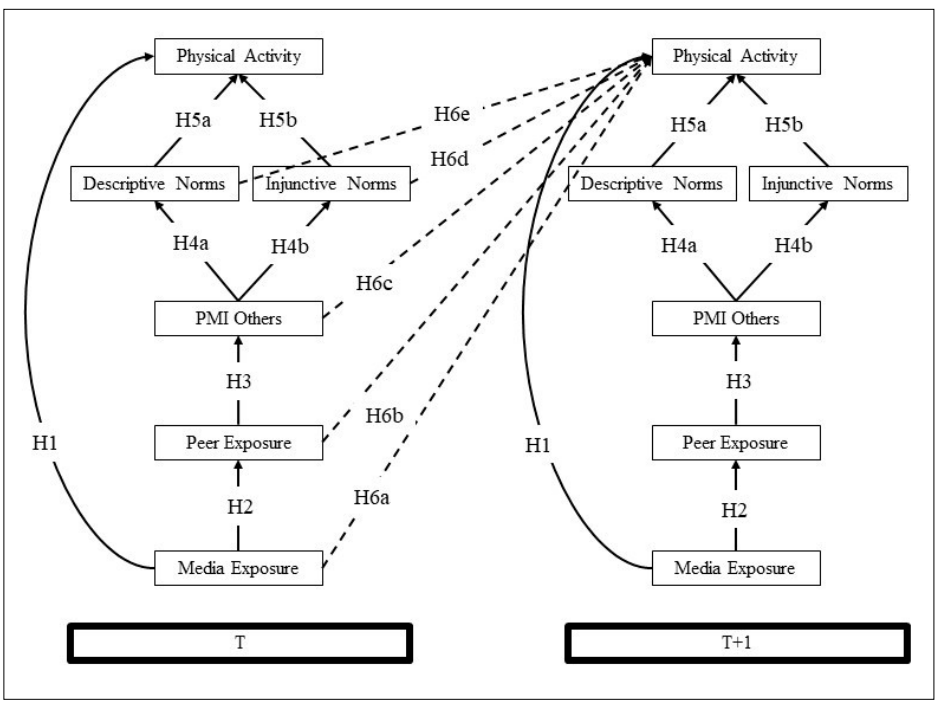
Some initial studies have addressed this research gap by analyzing assumptions about indirect media effects on people's behaviors using experimental or longitudinal designs (Dohle et al., 2017; Paek et al., 2011). For example, Tal-Or et al. (2010) used experimental methods to test IPMI hypotheses that perceived influence on others affects individuals' attitudes (Study I) and behaviors (Study II). The findings confirmed the IPMI assumptions in both studies, highlighting the significance of presumed media influence on attitudes and behaviors (Tal-Or et al., 2010, p. 820). A two-wave panel study by Paek et al. (2011) found that while media exposure (T1) did not directly affect attitudes (T2), its indirect effect (T1), mediated through presumed influence on others (T2), did shape attitudes (T2). These findings suggest that the perceived peer influence of media content on attitudes and behaviors develops over time (Paek et al., 2011, p. 139). There is a need for more IPMI research

that employs longitudinal or experimental designs. Therefore, this study employs a longitudinal research design.

Based on the assumption that behavioral change in physical activity unfolds gradually (Aira et al., 2021, p. 2; Perry et al., 2023, p. 1725), whereas perceptual variables (e.g., exposure, perceived influence, and norms) are likely to adjust more quickly, we focused on examining how adolescents' physical activity changes over time. Consequently, we did not test the exact sequential order among all preceding variables in the IPMI model, as doing so would have required a different, shorter time lag of measurements and at least five measurement points.

> *H6: Exposure to (a) physical activity content on social media, (b) perceived peer exposure to such content, (c) perceived influence on others, (d) perceived descriptive norms, and (e) perceived injunctive social norms at time t will influence adolescents' physical activity at subsequent time T + 1.*

Figure 1. Hypothesized model for influence of presumed media influence on physical activity content on social media on adolescents' physical activity over time



3. Materials and methods

3.1 Research design and procedure

This study was part of a larger research project, consisting of a three-wave longitudinal study involving adolescents in public schools in Switzerland. A random sample of 12 schools covering secondary, upper secondary, and vocational education was selected based on national education statistics (Bundesamt für Statistik, 2022). Schools were contacted by mail, e-mail, and telephone until participation was confirmed or declined. Of the 109 schools contacted, 12 participated in the study, including six upper secondary schools, three vocational schools, and three secondary schools.

Classes in the schools were selected to cover (late) adolescents in the age range of 14–18 years old. This focus was chosen due to substantial debate about changes in physical activity (Aira et al., 2021) and susceptibility to peer influence (Prinstein et al., 2001), but also due to practical reasons given by the Swiss school system and legal regulation for participation in surveys without parental consent. Some students in the selected classes were outside the defined age range. While students under the age of 14 were not allowed to participate in the survey for legal reasons, answers from students over the age of 18 were excluded post hoc.

Data were collected at the start of the school year (October/November 2023: N = 1,622, 51% female, 47% male, 2% non-binary, M_{age} = 15.48, SD_{age} = 1.15), in the middle of the school year (January/February 2024: N = 1,605, 52% female, 46% male, 2% non-binary, M_{age} = 15.75, SD_{age} = 1.22), and at the end of the school year (June/July 2024: N = 1,411, 50% female, 48% male, 1% non-binary, M_{age} = 16.06, SD_{age} = 1.19). The time points were selected to cover a full school year, with students in the same class to minimize the influence of changing group composition and other external factors. At each time point, the participants were informed about the study's purpose and provided consent before completing the online survey. Participation was voluntary, and students could opt out of the survey at any time without justification. The teachers did not supervise data collection, but the researchers did so to avoid any unintended pressure.

The survey, administered in German, is available in English on OSF (https://osf.io/s2ng7/). Variables were measured identically across all waves. As this study was part of a larger research project, participants were asked about social media use, physical activity, alcohol consumption, and sociodemographic information. The study was approved by the Institutional Review Board (NR. 23.04.27).

3.2 Participants

Only participants who participated in at least two of the three waves (N = 1,411) were included in the final sample. Participants who indicated that they did not use Instagram were excluded (n = 380). Consequently, the final sample consisted of 1,031 participants. Of these, 57% identified as female, 41% as male, and 2% as non-binary. At the start of the study (T1), participants were 14 to 18 years old (M = 15.46, SD = 1.14). A majority reported using Instagram several times a day

(60%), with an additional 23% using it daily. On days they used Instagram, they reported spending an average of one hour and eight minutes (*SD* = 2h 7 min) on the platform.

Regarding physical activity, 97% of participants indicated engaging in sports in their free time within the past six months. Among the remaining 3%, about half stated that they had regularly participated in sports before. Among the 97% physically active participants reported exercising daily (12%), at least once a week (80%), at least once a month (5%), or less frequently (3%) in the last six months.

3.3 Measures

Unless stated otherwise, items were measured using seven-point Likert-type scales ranging from 1 (e.g., *never* or *do not agree at all*) to 7 (e.g., *very often* or *fully agree*). Descriptive statistics for all measures across all three waves are shown in Table 1.

3.3.1 Media exposure

The adolescents were asked how often they were exposed to physical activity content on the social media platform Instagram. To further specify physical activity content, they were informed that physical activity included all possible forms of sports and exercise. Examples of various physical activity forms were given, like running, hiking, swimming, cycling, yoga, playing soccer, or any other leisure-time sports activity. The adolescents were informed that all physical activity on Instagram counts for their media exposure, regardless of whether they were actively looking for it or stumbling over it, and even if physical activity was not the core or only focus of the content. After these explanations, the participants were asked, "How often do you see posts of people engaging in physical activity on Instagram?". They could answer on a seven-point Likert-type scale from 1 (never) to 7 (very often).

3.3.2 Perceived peer exposure

The perceived exposure of peers to physical activity content on Instagram was assessed by asking participants how often they thought other adolescents their age were exposed to such content. Like media exposure and using the same scale, participants were informed that physical activity includes all forms of sports and were given examples before being asked, "How often do you think other young people your age see posts of people engaging in physical activity on Instagram?"

3.3.3 Presumed media influence on others

Items assessing social media's influence on others were derived from previous IPMI studies (Hong & Kim, 2020, p. 1804; Paek & Gunther, 2007, p. 415). Participants were asked how strongly they believed social media content referencing physical

activity influenced other adolescents to (1) start exercising, (2) engage in exercise more often, or (3) increase the time spent exercising.

3.3.4 Perceived descriptive social norms

Perceived descriptive social norms were measured with one item adapted from a similar assessment of adolescents' descriptive norms (Gunther et al., 2006, p. 58). Using a range slider, participants were asked to estimate how many people their age exercise at least once a week on a scale from 0 to 100%.

3.3.5 Perceived injunctive social norms

Perceived injunctive social norms were measured with one item based on a similar survey assessing injunctive norms for adolescents' health behaviors (Frey & Friemel, 2021). Participants were asked to estimate how people their age generally feel about others exercising less than once a week (1 = "not okay," 7 = "completely okay"). For the analysis, the item was recoded so that higher values represented stronger injunctive norms.

3.3.6 Physical activity

Participants were asked how many days in a typical week they engaged in physical activity outside of school or work, ranging from never (0) to daily (7) (Geusens & Beullens, 2021, p. 3).

Table 1. Descriptive statistics for all three waves.

	M	*SD*
Perceived media exposure		
T1	5.46	1.77
T2	5.47	1.68
T3	5.62	1.58
Perceived peer exposure		
T1	4.93	1.55
T2	4.88	1.50
T3	4.99	1.38
PMI others[a]		
T1	4.46	1.32
T2	4.52	1.25
T3	4.71	1.24

Descriptive social norms		
T1	65.26	20.29
T2	64.72	21.04
T3	64.74	20.25
Injunctive social norms		
T1	2.85	1.82
T2	2.99	1.78
T3	3.07	1.73
Physical activity (times/week)		
T1	3.43	2.15
T2	3.40	2.19
T3	3.52	2.08

Notes. Media Exposure, Peer Exposure, and PMI others: 7-point Likert-scales. Physical activity: days per week. Descriptive norms: 0–100% [a]Cronbach's alpha for mean-index. PMI others: T1: α = .88, T2: α = .89, T3: α = 92.

3.4 Analysis

We employed a cross-lagged panel model to test our hypotheses, calculated in R (R Core Team, 2024) with the lavaan package (Rosseel, 2011). Cross-lagged panel models, a type of structural equation modeling, are used to analyze longitudinal data (Mackinnon et al., 2022, p. 3). These models allow testing of causal hypotheses by incorporating cross-lagged paths (connecting different variables measured at different time points) and autoregressive paths (connecting the same variables across time points). Standardized regression effects are reported to account for differences in measurement scales.

To justify the use of a cross-lagged panel model (Hamaker et al., 2015, p. 103), we first confirmed that our data met key assumptions. We reshaped the data into long form and fitted three-level null models (measurements nested within individuals, classes, and schools) for each construct. School-level intraclass correlations (ICCs) were all below 0.05, indicating negligible clustering, and individual-level ICCs ranged from 0.32 to 0.66 (residual within-person variance: 0.30–0.68). These results demonstrate sufficient within-person fluctuation to identify autoregressive and cross-lagged effects and minimal bias from the nested sampling design, supporting the appropriateness of our cross-lagged panel approach.

All participants participated in at least two of the three waves. Participants with missing data were managed via full-information maximum likelihood estimation in lavaan, allowing each participant's available waves to contribute to the model. Cases with missing predictors were retained, ensuring that all two-wave participants informed the autoregressive and cross-lagged estimates.

4. Results

The results of the cross-lagged panel model are summarized in Figure 2 (Table A1). The overall model fit was assessed using the less restrictive thresholds of Hu and Bentler (1995, 1999): CFI ≥ 0.90, RMSEA ≤ 0.08, and SRMR ≤ 0.08. Given that (a) the model consisted of longitudinal data, (b) included cross-lagged and autoregressive paths, and (c) was calculated with a large sample (N > 1,000) (Chen, 2007; Marsh et al., 2004), the model showed an acceptable fit (RMSEA = 0.07, SRMR = 0.08). However, the CFI value (0.87) fell slightly below the threshold for a good fit, indicating potential for improvement.

Modification indices suggested including correlations between injunctive and descriptive social norms measured at the same time points. This correlation was deemed theoretically plausible, as injunctive and descriptive social norms describe related theoretical concepts (Lapinski & Rimal, 2005; Rimal & Lapinski, 2015). We decided to add these correlations to the model. The findings of the adapted model are reported below. This adaptation increased the model fit to a satisfactory level (RMSEA = 0.07, SRMR = 0.07, CFI = 0.91) without changes in the model's findings. This theoretically justified adaptation yielded a satisfactory fit and provided more consistent results across the three waves.

As a robustness check, we refitted the model, including age, gender, and school/class as covariates on wave 1 variables. The model fit indices slightly increased (CFI = 0.90, RMSEA = 0.05, SRMR = 0.06). The pattern and significance of the results remained unchanged except for one path,[1] which supports the robustness of our findings.

First, the autoregressive paths were analyzed. All effects were statistically significant (p < .001), with media exposure and physical activity strongly influenced by prior media exposure and physical activity, respectively. The relationships between peer exposure, presumed influence on others, and social norms over time were positive and of medium strength.

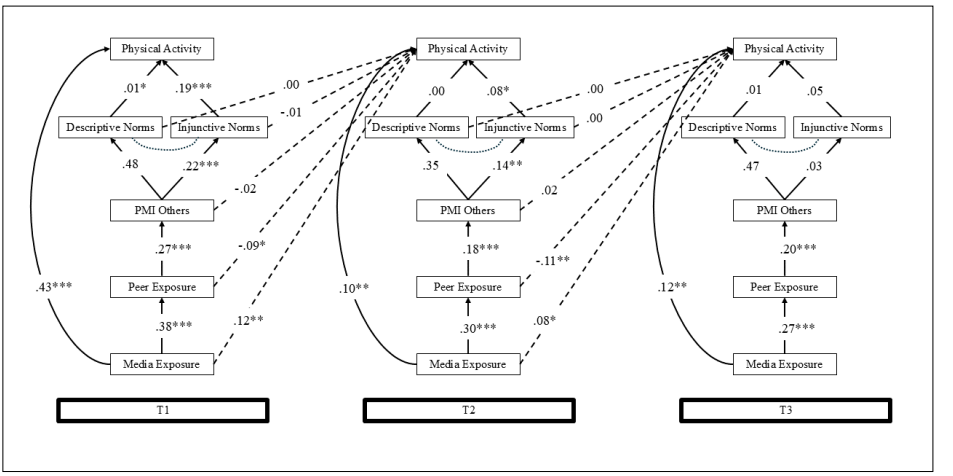
Second, the hypotheses were reviewed step by step. The direct effect of media exposure on physical activity, as assumed in H1, was confirmed. Media exposure to physical activity content on Instagram was positively related to adolescents' physical activity at the same time point (H1) and increased physical activity across time (H6a).

Hypotheses 2 to 5 posited an indirect influence of social media exposure to physical activity through perceived peer exposure, perceived influence on others, and perceived social norms on physical activity at the same time point. H6b–d proposed a mediated influence via these variables over time. Media exposure was positively related to adolescents' perceived peer exposure (H2 confirmed), which was positively related to their presumed media influence on others (H3 confirmed). Presumed influence on others was not positively related to descriptive social norms regarding physical activity (H4a rejected) but to their injunctive so-

1 In this adapted model, descriptive social norms did not significantly influence physical activity at T1. This is consistent with the lack of the same effect at T2 and T3 in the original and revised models.

cial norms at T1 and T2, although not at T3 (H4b partially confirmed). Descriptive norms were positively related to physical activity only marginally and only at T1 (H5a rejected), while injunctive norms were positively related to physical activity at T1 and T2 but not at T3 (H5b partially confirmed). Regarding the longitudinal effects, peer exposure at a given timepoint (T) significantly decreased physical activity at the next timepoint (T + 1), rejecting H6b, as the effect was in the opposite direction to what was assumed. The other effects on physical activity (T + 1) were insignificant for presumed media influence on others (H6c rejected), descriptive norms (H6d rejected), and injunctive norms (H6e rejected).

Figure 2. Influence of presumed social media influence referencing physical activity on adolescents' physical activity (standardized effects)



5. Discussion

This study focused on the influence of presumed social media influence on adolescents' physical activity through longitudinal data analysis. This is relevant because adolescence is a crucial phase in developing healthy habits, and social media is omnipresent in adolescents' lives (Buda et al., 2021, p. 1032). Based on the IPMI hypotheses, it was assumed that the influence of social media exposure on physical activity was mediated through perceived peer exposure, perceived influence on others, and perceived social norms (Gunther et al., 2006). By evaluating these assumptions in a longitudinal design, this study contributes to existing literature in several ways.

First, while IPMI hypotheses have been extensively analyzed in media research, particularly for health-related topics, few studies have examined them in relation to physical activity (Ho et al., 2016). Second, despite the assumed causal relationships implied by the hypotheses, most IPMI research has relied on cross-sectional survey data, which precludes causal inferences (Paek et al., 2011). This study addressed this limitation by employing a three-wave panel design. Third, most re-

search has focused on traditional mass media, which are less relevant in contemporary adolescents' lives. This study examined social media exposure to physical activity content, reflecting current media consumption habits.

Our findings confirm the direct effect of exposure to physical activity content on social media (i.e., Instagram posts) on adolescents' physical activity. Exposure to physical activity content on Instagram increased adolescents' physical activity both cross-sectionally and longitudinally. This aligns with previous studies showing a positive effect of fitness content on physical activity levels across various user groups (e.g., Goodyear, Boardley, Chiou, Fenton, Makopoulou, Stathi, Wallis, Veldhuijzen van Zanten, Wood, et al., 2021, p. 10; Johns et al., 2017).

The findings for the indirect media effect only partially supported the IPMI hypotheses. The pathway through injunctive social norms was largely consistent with prior findings (except at W3) and consistent with previous studies (Chia, 2006; Ho et al., 2016). The pathway through descriptive norms was not confirmed at any wave, contradicting earlier research (Gunther et al., 2006; Hong & Kim, 2020). Addressing criticisms of cross-sectional IPMI analyses (e.g., Bernhard & Dohle, 2018, p. 463; Cheng & Chen, 2020, p. 723), we analyzed the relationships between media exposure (H6a), peer exposure (H6b), presumed influence on others (H6c), descriptive (H6d), injunctive norms (H6e) on physical activity over time.

Presumed media influence on others, descriptive norms, and injunctive social norms showed no significant effects on subsequent physical activity. Peer exposure exhibited a negative effect on physical activity. This unexpected finding raises questions. While the assumed exposure of peers to physical activity content on social media was positively associated with physical activity cross-sectionally – mediated through presumed influence on others and injunctive norms – it directly decreased physical activity at the next time point. Although this negative effect was relatively small, it was consistent across the two intervals. A potential explanation for this finding is that adolescents' traits or the type of physical activity may be moderators of this relationship. For example, adolescents with low self-esteem who perceive their peers as highly exposed to physical activity content may fear that others are better at physical activities commonly performed in public gyms or in groups (e.g., yoga, weight training), leading them to refrain from participation.

With respect to the role of social norms, our findings contradict other IPMI studies that emphasized the relevance of descriptive norms for various health-related behaviors (Gunther et al., 2006; Hong & Kim, 2020) and general evidence supporting the influence of descriptive social norms on physical activity (for an overview, see Kim et al., 2019). With respect to adolescents' Instagram use, perceptions of socially approved behaviors (injunctive social norms) are more likely to be relevant than the perception of actual behavior (descriptive social norms; Cialdini et al., 1990). This may be explained by a general divergence between approving physical active and *actual* physical activity. While physical activity is widely recognized as healthy, many people are not as active as they would like to be or should be (Nilsen et al., 2023, p. 101394; World Health Organization, 2024).

Another explanation for the limited influence of descriptive social norms on physical activity may lie in findings from other studies, suggesting that mediators or moderators play a role in this relationship. For example, the theory of normative social behavior posits that injunctive social norms moderate the influence of descriptive social norms on behavior (Rimal & Lapinski, 2015, p. 398). Contextual factors, such as privacy and ambiguity, may also be relevant (Chung & Rimal, 2016, p. 11). Hong and Kim (2020) demonstrated that for private, sensitive topics such as condom use intentions, descriptive social norms mediated the influence of presumed media exposure on behavior. Conversely, for the public, less ambiguous topics such as healthy eating or sunscreen use, presumed media influence directly affected people's behavior (Hong & Kim, 2020, p. 1807). These individual and contextual characteristics warrant further investigation to clarify the relationship between social norms and physical activity (Chung & Rimal, 2016, p. 16f).

Differences in how IPMI models are operationalized may also explain the inconsistencies across studies. Some research has examined the direct effect of perceived influence on others on behavior (Dohle et al., 2017), while other studies have introduced mediators such as social norms (Ho et al., 2016), attitudes toward the behavior of interest (Gunther et al., 2006), or perceived influence on oneself (Cho et al., 2021). These modeling differences, along with variations in research topics and media analyzed, likely contribute to discrepancies in the findings.

When reflecting the study's findings, it is also important to consider other possible outcome variables than physical activity. The influence of media exposure to physical activity content on social media on adolescents' physical activity may appear to be a positive media effect. Possible negative effects should also be considered. This includes potential negative effects of exposure to physical activity content on Instagram (e.g., fitspiration) on body satisfaction or as driver for excessive thinness or muscularity (Easton et al., 2018; Jerónimo & Carraça, 2022; Sukamto et al., 2019). Physical activity may not be the outcome of interest. In other areas, research has shown the importance of the exact content consumed on social media rather than the duration of use (Sanzari et al., 2023, p. 6). Future research should focus on the specific content to which adolescents are exposed to further shed light on the relationship between physical activity content and their attitudes, intentions, and behaviors.

5.1 Limitations

This study has some limitations that require discussion. First, the reference group of "other adolescents your age" had to be kept vague to apply to all study participants. For athletes, the relevant referent groups may not include all adolescents but rather an active subset such as other team members or athletes in their league (Spink et al., 2013, p. 815). The broad specification of the reference group may have influenced these findings (Shulman & Levine, 2012, p. 547). It is possible that social norms regarding the prevalence of physical activity within the general age group were less relevant than norms within close peer groups. Future

studies should explore whether the prevalence of physical activity among adolescents' close friends influences physical activity over the long term.

Second, the one-year time frame does not allow accounting for dynamics that develop within shorter or longer time frames. For example, a meta-analysis found that physical activity changes occur earlier for girls (9–12 years) than boys (13–16 years) (Dumith et al., 2011, p. 695). Seasonal influences, which have been shown to influence adolescents' physical activity in other studies (Carson & Spence, 2010), were not accounted for. Defining the ideal research design becomes even more complicated as media use and its subsequent effects may occur in a much shorter timeframe. Hence, selecting the optimal time lag in panel studies in general (Dormann & Griffin, 2015; Griep et al., 2021) and in digital media research (Vandenbosch et al., 2025) will remain a challenge for future IPMI research on physical activity.

Third, physical activity was measured based on how often the adolescents engaged in physical activity during a typical week. This measure did not account for changes in the intensity or duration of physical activity. Other possible influences of social media content related to physical activity were also not examined. Physical activity content may motivate adolescents to try new activities, adjust their training plans, or add new exercises to their routines. Future research should gather more information on adolescents' physical activity to further explore these dimensions.

Fourth, exposure to physical activity content was measured using retrospective self-reports. These self-reports may be biased in several ways, such as over-estimation due to a single extensive episode (Schwarz, 2008). Our measurement did not distinguish between social media content actively sought and content on physical activity that adolescents were accidentally exposed to. This differentiation might have influenced our findings and should be further disentangled in future research. Exposure to physical activity content was only assessed for Instagram and did not include other social or mass media platforms. Consequently, other media influences (e.g., from TikTok or television) were not considered. Physical activity content on Instagram may encompass a wide range of content. Future research should dive further into the exact contents to which adolescents are exposed, for example, through the collection of tracking data or data donations covering the exact social media content to which adolescents were exposed.

Fifth, like all statistical models, cross-lagged panel models can be discussed critically, and one needs to acknowledge their presumptions and limitations regarding the interpretation of causal influences in longitudinal panel data (Hamaker et al., 2015, p. 104). Future research with a similar design could consider random-intercept CLPM (Hamaker et al., 2015, p. 105) to separate within- and between-person effects and focus on achieving satisfying statistical power on each level (Scherbaum et al., 2019).

5.2 Conclusion

This study provides important insights into the complex relationship between social media exposure and adolescents' attitudes and behaviors. Based on a longitudinal application of the IPMI hypotheses and a three-wave panel survey on social media use and physical activity, the findings show that exposure to physical activity content on social media has both direct and indirect effects on adolescents' physical activity levels. Indirect effects operate through perceived peer exposure to such content, perceived influence of this content on others, and the perceived injunctive social norms of physical activity. In contrast to other studies, no such effects were found for descriptive social norms. Descriptive norms were neither influenced by presumed influence on others nor influenced physical activity.

When adolescents are exposed to Instagram content featuring people exercising, posting gym photos, or showcasing workout routines, they increase their subsequent physical activity. This effect persisted over time, highlighting the importance of social media content for adolescents' behavior during this critical phase of developing healthy lifestyle habits (Aubert et al., 2021). Beyond these topic-specific insights, the findings contribute to the literature on social media's impact on adolescents' health-related behavior in the broader IPMI framework. This study is among the few to use a longitudinal design to evaluate the direct and indirect effects of social media. The results suggest the need for further investigation into the distinct roles of descriptive and injunctive norms, the influence of different reference groups, and the need to account for dynamics at different time scales (i.e., shorter time lags for measures of media exposure and perception variables than for behavior change).

With respect to practical implications, these findings underscore the relevance of social media content in public health discussions and strategies to motivate adolescents to adopt healthy lifestyles. For example, the WHO (2024, p. WHO response, 6) aims to reduce physical inactivity by 15% by 2030. Supporting influencers who promote evidence-based health content on social media could be a valuable component of this strategy.

Generative AI declaration

AI-based tools were used to support language editing, including rephrasing sentences for clarity and coherence, and improving the structure and readability of the manuscript. All substantive content, theoretical arguments, and interpretations were developed by the authors.

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Appendix

Table A1. Results for the influence of presumed media influence on physical activity.

	β	*SE*	*z*	*p*	95% CI	
H1						
Physical activity – media exposure (T1)	.43	.04	11.00	<.001	[.35,	.50]
Physical activity – media exposure (T2)	.10	.04	2.79	.005	[.03,	.20]
Physical activity – media exposure (T3)	.12	.04	3.04	.002	[.04,	.20]
H2						
Peer exposure – media exposure (T1)	.38	.03	13.23	<.001	[.32,	.43]
Peer exposure – media exposure (T2)	.30	.03	7.94	<.001	[.24,	.35]
Peer exposure – media exposure (T3)	.27	.03	9.11	<.001	[.21,	.32]
H3						
PMI others – peer exposure (T1)	.27	.03	9.34	<.001	[.21,	.32]
PMI others – peer exposure (T2)	.18	.03	7.49	<.001	[.14,	.23]
PMI others – peer exposure (T3)	.20	.03	6.77	<.001	[.14,	.26]
H4a						
Descriptive norms – PMI others (T1)	.48	.53	.91	.362	[-.55,	1.51]
Descriptive norms – PMI others (T2)	.35	.50	.69	.488	[-.63,	1.32]
Descriptive norms – PMI others (T3)	.47	.53	.89	.376	[-.57,	1.51]
H4b						
Injunctive norms – PMI others (T1)	.22	.05	4.59	<.001	[.13,	.32]
Injunctive norms – PMI others (T2)	.14	.04	3.23	.001	[.28,	.41]
Injunctive norms – PMI others (T3)	.03	.05	.71	.480	[-.06,	.12]
H5a						
Physical activity – descriptive norms (T1)	.01	.00	2.15	.032	[.00,	.01]
Physical activity – descriptive norms (T2)	.00	.00	.74	.461	[-.00,	.01]
Physical activity – descriptive norms (T3)	.01	.00	1.68	.094	[-.00,	.01]
H5b						
Physical activity – injunctive norms (T1)	.19	.04	4.59	<.001	[.11,	.26]
Physical activity – injunctive norms (T2)	.08	.03	2.41	.016	[.02,	.15]
Physical activity – injunctive norms (T3)	.05	.04	1.37	.172	[-.02,	.12]
H6a						
Physical activity (T2) – media exposure (T1)	.12	.04	2.87	.004	[.04,	.20]
Physical activity (T3) – media exposure (T2)	.08	.04	2.02	.043	[.00,	.16]

H6b						
Physical activity (T2) – peer exposure (T1)	-.09	.04	-2.16	.031	[-.17,	-.01]
Physical activity (T3) – peer exposure (T2)	-.11	.04	-2.71	.007	[-.19,	-.03]
H6c						
Physical activity (T2) – PMI others (T1)	-.02	.04	-.35	.725	[-.10,	.07]
Physical activity (T3) – PMI others (T2)	.02	.05	.33	.741	[-.07,	.10]
H6d						
Physical activity (T2) – descriptive norms (T1)	.00	.00	-.45	.651	[-.01,	.00]
Physical activity (T3) – descriptive norms (T2)	.00	.00	-.63	.527	[-.01,	.00]
H6e						
Physical activity (T2) – injunctive norms (T1)	-.01	.04	-.18	.857	[-.07,	.06]
Physical activity (T3) – injunctive norms (T2)	.00	.04	-.11	.911	[-.08,	.07]
Autoregressive paths						
Media exposure (T2) – media exposure (T1)	.52	.03	18.95	<.001	[.46,	.57]
Media exposure (T3) – media exposure (T2)	.47	.03	15.23	<.001	[.41,	.53]
Peer exposure (T2) – peer exposure (T1)	.25	.03	7.94	<.001	[.19,	.32]
Peer exposure (T3) – peer exposure (T2)	.30	.03	9.49	<.001	[.24,	.36]
PMI others (T2) – PMI others (T1)	.34	.03	11.59	<.001	[.28,	.39]
PMI others (T3) – PMI others (T2)	.42	.03	13.11	<.001	[.35,	.48]
Descriptive norms (T2) – descriptive norms (T1)	.35	.03	10.78	<.001	[.28,	.41]
Descriptive norms (T3) – descriptive norms (T2)	.40	.03	12.80	<.001	[.34,	.46]
Injunctive Norms (T2) – injunctive norms (T1)	.42	.03	13.95	<.001	[.36,	.48]
Injunctive Norms (T3) – injunctive norms (T2)	.46	.03	14.49	<.001	[.40,	.53]
Physical Activity (T2) – physical activity (T1)	.67	.03	26.26	<.001	[.62,	.72]
Physical Activity (T3) – physical activity (T2)	.62	.03	23.53	<.001	[.56,	.67]

Notes. Results of the cross-lagged panel model with standardized regression coefficients. R^2: Peer exposure T1 = .19, T2 = .22, T3 = .24; PMI others T1 = .10, T2 = .19, T3 = .24; Descriptive norms T1 = .00, T2 = .11, T3 = .18; Injunctive norms T1 = .03, T2 = .20, T3 = .23; Physical activity T1 = .16, T2 = .53, T3 = .49.