Binge-Watching and its impact on physical health: The association of binge-watching and (daily) physical activity

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Abstract

Video-on-demand streaming services are rising, changing how series are watched strongly. With that development, the phenomenon "binge-watching" has emerged. Research to define that term and to investigate predictors and consequences, especially with regards to physical health, is still in the beginning at an early stage. Therefore, the research questions of this study were if general physical activity is associated with binge-watching behaviour and if binge-watching behaviour is associated with daily physical activity (light-intensity and vigorous-intensity activities) over a period of 13 days. These were answered by a two-week experience-sampling study. Participants (n=45) were asked to use the app "Ethica" to answer a baseline questionnaire and daily retrospective questionnaires. Linear Mixed Model analyses were performed and demonstrated that there was neither a significant association between general physical activity nor the number of hours/episodes watched, nor between daily physical activity and the number of hours/episodes watched. The current study did not confirm the often assumed negative effects of VoD-watching on physical activity. It is suggested that future research chooses a sample that is more representative for the at-risk population to confirm the absence of an association between binge-watching and physical activity and to investigate other potential effects of binge-watching on physical health.

Keywords: Binge-watching, physical activity, experience-sampling study, Ethica

Introduction

Since television broadcasting began in 1928 in the USA, it has continuously developed. From black-and-white television, to cinemas, to 3D-movies to, more recently, the emergence of video on demand streaming websites like Netflix, Amazon Prime and YouTube. Not only are the options for where to watch series expanding, but also the way we consume it. Waiting for episodes to come out weekly are problems of the past since most video-on-demand streaming services publish whole seasons at once, enabling viewers to binge-watch. Since this watching behaviour is mostly done sedentary, the current study aimed to examine the consequences of binge-watching behaviour on the physical activity of people who execute binge-watching behaviour regularly.

Due to the gaining popularity of streaming services like Netflix or Amazon Prime, a new milestone was set within the history of television. With Netflix having almost 170 million paid memberships around the world, it has become a strong competitor to traditional television (Netflix, n.d.). According to a statistic by Watson (2019) on Statista, the stagnation of traditional TV in the upcoming years is predicted. Reasons for the growth of video-on-demand streaming websites are that the customers have access to a wide variety of series and movies and thus, are more flexible than when watching traditional television. Video-on-demand websites, as the ones named above, offer diverse options that cover multiple genres with regards to movies and series from psych thrillers to movies for children. Moreover, the viewer can access complete seasons and watch them entirely since these are published at once, so no waiting is involved. With streaming services such as Netflix that publishes whole seasons immediately, so-called “binge-watching” behaviour started to develop.

More and more studies are published each year that deal with the motives and consequences of binge-watching. Nevertheless, studies have not agreed on one single definition of binge-watching yet. A systematic review by Flayelle et al. (2020) found out that there have been almost 20 different definitions used in studies so far. Still, most studies agree that binge-watching includes the watching of more than three hours or more than three episodes of the same series in a single sitting (Flayelle et al., 2020). Before this definition is used as a base for this research, the statistics about Netflix use are demonstrated. For this, the definition of Netflix’ survey is used which implies a minimum of two episodes need to be watched for it to be defined as binge-watching. These results were taken from an online study that surveyed approximately 3.000 adults aged 18 and older from the United States of America. It was discovered that 61% of the participants binge watched on a regular basis,

watching two to three episodes each session (West, 2018). Therefore, it can be concluded that binge-watching is already part of the population's daily life and not a trend that is yet to occur in the near future.

Even though binge-watching behaviour is already a substantial part of our lives, this relatively new phenomenon and its predictors and consequences still needs to be more researched. To explore what is already known about these predictors and consequences, the first systematic review concerning binge-watching research was published at the beginning of this year (Flayelle, 2020). This review operationalized binge-watching, assessed the prevalence of binge-watching, investigated the profiles of binge-watchers, and listed the outcomes of binge-watching and finally its correlation with mental health. In the following, the conclusions of this systematic review are introduced.

With respect to predictors of binge-watching, for instance, an exploratory, cross-sectional study found that binge-watching sessions lasted longer among the male population (Exelmans & Bulck, 2017). Additionally, it was found in one study that generally younger persons demonstrate higher binge-watching frequency (Flayelle et al., 2020). Common motives for binge-watching resulted from a survey by Flayelle et al. (2019), namely sensual, eudaemonic and reward-based motivations. Additionally, the postponement of obligations and emotion regulation purposes were highlighted as reasons for binge-watching.

Apart from the systematic review, Dandamudi & Sathiyaseelan (2018) summarised five, both positive and negative, main motives that were given to explain what drives binge-watching behaviour based on present literature. It was found that boredom was one of the motives behind binge-watching because it keeps one entertained (McIlwraith, 1998). Secondly, watching television was found to be relieving since it offers the viewer a possibility to escape from their stress (Panda & Pandey, 2017). Thirdly, loneliness facilitated binge-watching due to the stronger parasocial relationships and the sense of belonging one is experiencing (Eyal & Cohen, 2006; Greenwood & Long, 2009). Fourthly, binge-watching was perceived socially acceptable and even supports social engagement (Panda & Pandey, 2017). A reason for that is the facilitated participation to join conversations with one's peer group. Finally, binge-watching was part of the daily routine of many people and becomes a habit in many cases (Mikos, 2016).

Besides predictors and motives for binge-watching, some research has examined what advantages and disadvantages binge-watching brings with it. On the one hand, binge-watching appears to have some benefits since it is, for example, related to higher levels of amusement and the development of closer parasocial relationships to the characters of a show

(Flayelle et al., 2020). On the other hand, the systematic review also found a link between binge-watching and insomnia, reduced sleep quality and daytime fatigue. Also, healthy diet correlated negatively with overall binge-watching. In addition to that, mental health-related issues can occur as a result of binge-watching. According to Flayelle et al. (2020), examples of depression, anxiety and symptoms that are usually connected to addictions were also found in self-report studies of severe binge-watchers. Nevertheless, these results are not clear yet due to the inconsistent definitions that were used in various papers and limitations in the used study designs.

Most studies so far used cross-sectional survey study designs. Nevertheless, these do not allow causal inferences (Flayelle, Maurage, Vögele, Karila, & Billieux, 2018) and suffer from several additional limitation. Therefore in the current study another technique is used, namely the experience sampling method which is a momentary experience assessment technique (Verhagen, Hasmi, Drukker, Os, & Delespaul, 2016). This method requires participants to report their thoughts, feelings or behaviour multiple times within a specified time frame (Conner & Lehman, 2012). Even though ESM also does not allow causal inferences, it provides more clues about temporal associations over time. Moreover, it allows the subjects to stay in their natural environment and thus, artificial conditions for testing are not needed. Furthermore, it has benefits compared to other research methods. For example, it uses momentary assessments, close to the actual moment of feelings and behaviours, instead of retrospective self-report studies. This is more beneficial because self-report measurements presume that participants can accurately reflect on their behaviour even though this cannot be guaranteed (McDonald, 2008).

Apart from the advantages named above, ESM is suitable when being interested in the within-subject effect. A within-subject effect concerns the variability of a certain condition for an individual within a sample (Van de Pol & Wright, 2009). Study designs as surveys generate less data of individual participants than ESM does. The advantage of those multiple assessments over time is that it allows a more detailed insight into fluctuations of, for example, a participant's mood or mental state (Verhagen et al., 2016). Thus, it obtains more in-depth data of single participants and allows the investigation of within-subject effects which is suitable for this study since it deals with the relation between an individual's physical activity and when he/she binge-watches regularly.

Furthermore, it ensures more accurate data since it is measured in the actual moment (e.g. after binge-watching) over a prolonged time. Additionally, the data is collected at different times of the day and week. Thus, it gives insight into the variability of the measured

construct. Apart from that, ESM allows investigation that takes place in the participant's natural environment which increases the ecological validity and is thus, more representative of the actual behaviour of the participant (Larson & Csikszentmihalyi, 2014). Finally, the repeated measurement over time increases the validity and reliability of different measures due to reduced assessment error (Verhagen et al., 2016).

One potential consequence of binge-watching that is often assumed in popular media, but that has barely received attention in research is the relation between binge-watching and physical activity. Even though there are already studies available that examine the connection between binge-watching and sleep patterns or mental health, evidence about the connection to physical activity is scarce. The relevance for investigation is relatively high since this activity is mainly performed while laying or sitting. It gains even more relevance when looking at the physical health consequences of sedentary behaviour in general since it is generally known to have drawbacks for humans' physical health as well. As Pate, O'Neill, & Lobelo (2008) define it, sedentary behaviour includes "activities that do not increase energy expenditure substantially above the resting level and includes activities such as sleeping, sitting, lying down and watching." Thus, activities like slow walking or cooking food do not belong to sedentary behaviour but light physical activity (Pate, O'Neill, & Lobelo, 2008). According to this definition, binge-watching can be considered as predominant sedentary behaviour.

Several studies have already shown that health issues can arise from predominant sedentary behaviour. For instance, in a study it was demonstrated that sedentary behaviour is associated with an overall poor health (Yancey et al., 2004). Additionally, another study demonstrated a link between sedentary behaviour in males and colorectal cancer risk in the United Kingdom (Morris, Bradbury & Cross, 2018). Moreover, predominant sedentary behaviour develops susceptibility for an increasing risk of obesity and type 2 diabetes mellitus which can be lowered with light to moderate activity according to Hu (2003). Furthermore, research shows that prolonged sitting is one risk factor for cardio metabolic diseases and overall mortality (Owen, Sparling, Healy, Dunstan, & Matthews, 2010).

Research that focused on sedentary behaviour due to traditional television watching found mainly two health risks. First of all, it was found out that males who watched more than four hours of television daily had an elevated risk of 35% to develop colorectal cancer compared to the control group that watched a maximum of one hour daily. Secondly, an Australian study showed that participants were twice more likely to be overweight when watching more than four hours of television per day than when watching only one hour daily, not considering their physical fitness level (Salmon, Bauman, Crawford, Timperio, &

Owen,2000). Moreover, a study by Lori Spruance focused especially on binge-watching. The study demonstrated three main things: 1) the higher the time spend in front of the TV, the less time one spends on physical activity 2) non-binge-watchers are more probable to meet the physical activity recommendations as compared to binge-watchers and 3) more than 20% of binge-watchers are overweight or even obese (Spruance, Karmakar, Kruger ,& Vaterlaus, 2017).

These studies do not only emphasize that less sitting is crucial to live a long and healthy life, but also draw attention to the global recommendations on physical activity. For people aged 18-64 these recommendations are as follows: moderate-intensity aerobic physical activity should be done at least for 150 minutes weekly. Another option is a minimum of 75 minutes of vigorous-intensity aerobic physical activity divided throughout the week or an equivalent combination of both options (World Health Organization, 2004). In addition to that, aerobic activity should be done within one week in bouts of 10 minutes at least even though more exercise is suggested for a healthier lifestyle.

So far, a lack of research about how binge-watching affects the physical activity of the sample population exists. Therefore, this study aims to examine the consequences of binge-watching behaviour on the daily light and vigorous physical activity of the sample population within a time frame of two weeks.

RQ1: Is the general physical fitness of the sample group associated with daily binge-watching behaviour?

RQ2: Is daily binge-watching over a time frame of 13 days significantly associated with the light physical activity of the sample group within individuals over time?

RQ 3: Is binge-watching over a time frame of 13 days significantly associated with the vigorous physical activity of the sample group within individuals?

Methods

Design

This research used an experience sampling method (ESM) design which enabled the longitudinal daily measurement of both watching behaviours and physical activity. Over a period of 13 days, the participant's daily binge-watching behaviour and physical activity was measured through questionnaires. The data collection for all participants started on April 7th 2020 and ended on 20.04.2020 (Table 1).

Table 1. Measurements for each day with the exact date.

Day	Date
Baseline Questionnaire	07.4.2020 – Tuesday
0	08.04.2020 – Wednesday
1	09.04.2020 – Thursday
2	10.04.2020 – Friday
3	11.04.2020 – Saturday
4	12.04.2020 – Sunday
5	13.04.2020 – Monday
6	14.04.2020 – Tuesday
7	15.04.2020 – Wednesday
8	16.04.2020 – Thursday
9	17.04.2020 – Friday
10	18.04.2020 – Saturday
11	19.04.2020 – Sunday
12	20.04.2020 – Monday

The questionnaires were employed with the smartphone application Ethica which is a survey software. Ethica can be downloaded for free in all appstores and gamestores and is thus easily accessible for participants. All of the questionnaires were presented in English. The study consisted of two questionnaires, the baseline- and the daily retrospective questionnaire.

Since the participants indicated their behaviour autonomously, the study used active measurements of the participants (Connor & Lehman, 2012). Moreover, this research used variable sampling because participants received notifications when to fill out certain questionnaires. Even though the periods were fixed, the signals succeed randomly within those intervals and thus, change from measurement to measurement. The baseline questionnaire was prompted on day 1 and was published between 9 a.m. and 9:10 a.m. The time of filling out that questionnaire was considered irrelevant because it asked about general behaviour and demographics that were not prone to change within the timeframe of the study. Therefore, the time for answering the baseline questionnaire did not expire.

Next, a daily retrospective questionnaire was published each morning randomly

between 9 a.m. and 11 a.m. and expired after 24 hours before the new one appeared in the application. This daily questionnaire asked about the amount of hours they binge-watched the previous day, at what time they started and for how long they watched on the previous day. With regards to physical activity, it was asked for how many minutes light-intensity and vigorous-intensity activities were executed on the day before.

In previous experience sampling studies the median number of included subjects was 19 participants (Berkel, Ferreira & Kostakos, 2018). Based on that, this study aimed for a sample size of 45 participants to account for potential missing data.

Moreover, the study duration was 13 days based on the survey of Berkel, Ferreira & Kostakos (2018) recommending a median study duration of 13 days for ESM studies. Another characteristic of ESM studies is to measure behaviour or feelings multiple times a day. Here, the number of measurements was set to once daily. Since the daily measurement only asked about physical activity and binge-watching behaviour retrospectively which does not change anymore, asking it once was considered sufficient.

Participants

The sample population was very roughly defined since this was a relatively new research area that still needed to be explored. Thus, an age limit, a specific occupation or the country of residence was no condition that needed to be fulfilled in order to participate. Nevertheless, four inclusion criteria needed to be fulfilled to be a suitable participant for this study. First of all, the participants needed to have access to video-on-demand streaming services. Secondly, the participants needed a technical device, with either Android or IOS, to download the app Ethica. Third, they needed to be over the age of 18. Finally, all participants needed sufficient English language skills to understand the questionnaires.

For this study, 45 participants were recruited through convenience sampling through social contacts. Since two participants filled out less than 50% of the daily questionnaires, 43 participants were included in the data analysis (Connor & Lehman, 2012). The participants' age ranged from the age of 20 until 65, with a mean age of 24.5 (SD= 7.2); 32 participants (74.4%) were female and 11 (25.6%) were male. The participants had different nationalities (84.1% German, 4.5% German-Turkish, 4.5% Turkish, 4.5% Mexican, and 2.3% American). Moreover, the participants were students (56.8%), full-time-workers (40.9%), or pupils (=2.3%).

Materials

A mobile app named Ethica was used to conduct the ESM study. Within this app, five additional daily questionnaires were included since this study is part of a bigger study that also investigates the connection between binge-watching and snacking and binge-watching and mood and introversion. Nevertheless, this research paper focused only on the connection between binge-watching and physical activity and excluded all information and data related to mood, introversion and snacking.

Baseline Questionnaire.

The baseline questionnaire contained 23 items that asked about the demographic data of the participant and the general physical fitness of the participant (Appendix A). The first demographic questions were "How old are you?" that needed to be indicated with a number. Secondly, it was asked to indicate their gender with either "male", "female" or "other". Thirdly, the reply options "pupil", "student", "full-time worker", "part-time worker" and "other" were given to indicate the participant's occupation. The fourth item asked to specify the nationality in a free form text format. Finally, a multiple-choice format was given to indicate which video-on-demand streaming services respondents typically used. Reply options were "Netflix", "Amazon Prime", "YouTube", "Sky" and "other".

After answering the five demographic questions, the 16 items of the Global Physical Activity Questionnaire (GPAQ) were used to investigate the general physical fitness of the participant. This questionnaire consisted of five yes-and-no questions and 11 fill-in questions and covered the areas work, travel, recreational activities and sedentary behaviour. The GPAQ has been proved to be a reliable and validated mean to measure general physical activity (Bull, Maslin, & Armstrong, 2009; Herrmann, Heumann, Ananian, & Ainsworth, 2013). Especially good results in terms of test-retest reliability in studies whose period ranged from three days to two weeks has been found (Keating, et al., 2019).

The gathered data of the GPAQ was then transformed into Metabolic Equivalent (MET) values according to the analysis guide by WHO (World Health Organization, 2012). MET values are used to determine the intensity of physical activities to analyse the general physical fitness of subjects. MET is defined as "the ratio of a person's working metabolic rate relative to the resting metabolic rate" (World Health Organization, 2012, p.3). One MET describes the energy expansion while sitting quietly, relatively to the weight of a person (World Health Organization, 2012). When using the GPAQ, moderate activities request a four

times higher energy exposure and vigorous activities request an eight times higher energy exposure than compared to sitting quietly. Thus, moderate-intensity activities are allocated with a MET of 4 and vigorous-intensity activities with a MET of 8 when calculating a subject's general energy exposure.

Daily Retrospective Questionnaire.

The daily questionnaire was divided into two parts, namely binge-watching behaviour and physical activity on the preceding day (Appendix B). All six items were developed by the researchers to investigate the participant's watching behaviour and physical activity retrospectively. The first binge-watching question asked "Did you watch video-on-demand services yesterday?" which could be answered with yes or no to indicate if the participant used such streaming services that day. "How many episodes did you watch yesterday?" was asked to specifically assess the number of episodes ranging from "Less than one episode" to "More than 7 episodes". In addition to that, the option "I did not watch" and "I watched a movie" were given as well. Finally, the question "How long did you watch video-on-demand content yesterday? to investigate the amount of time the participants spent watching. Reply options ranged from "Less than one hour" up to "More than 7 hours". Moreover, the option "I did not watch any" was given.

The second item that measured the amount of episodes and the third item that measured the amount of hours were transformed into numerical data. The number of episodes and hours was transformed into numbers. Thus, 1 episode/hour was coded as 1. "Less than one episode/hour" was coded into the value 0.5 and "More than 7 episodes/hours" was coded into the value 7.5. The reply options "I did not watch anything" and "I watched a movie" were coded into the value 0 and thus, excluded from the analysis.

With regards to the questions about physical activity, it was asked how many minutes they performed a specific intensity-type of an activity in order to heighten precision as many self-assessment studies have also done in the past. Additionally, there are also other ESM studies available that ask about the amount of time in minutes and the indication of the intensity of physical activity when investigating daily physical activity (Kanning, Ebner-Priemer, & Schlicht, 2013). Thus, the questions "How many minutes did you do light-intensity activities that require minimal physical effort and cause only minimal increases in breathing or heart rate yesterday? (e.g. housekeeping, walking, bowling)" and "How many minutes did you do vigorous-intensity activities that require hard physical effort and cause large increases in breathing or heart rate yesterday? (e.g. running, jogging, swimming)" to

indicate how many minutes the participant executed light-intensity and vigorous-intensity activities the day before was asked. The amount of minutes was then coded into numeric data (e.g. , 30 minutes has the value 30).

Procedure

On March 23 2020, ethical approval from the Ethical Committee of the Faculty of Behavioural Sciences of the University of Twente was given. Thereupon, data was collected with the smartphone application Ethica. Before day 1 of the study, the participants received two emails. One registration mail from Ethica, containing the download link for the app and the registration code, and one invitation written by the researchers. The latter included a description of the study and two links: one that linked to the appstore/game store to download Ethica and one that linked to the study (Appendix C). Moreover, the start and end of the study was emphasized to make sure that all participants started using the app on the same day to facilitate statistical analyses. When opening the study, the informed consent was presented which included the purpose of the study, the study procedure, information about confidentiality and participation as well as the contact information of the researchers. When clicking on "continue" participants automatically agreed to the informed consent.

On the first day of the study, the participants were asked to fill out the baseline questionnaire that was published between 9 a.m. and 9:10 a.m. From day 2 to 15, the daily retrospective questionnaire needed to be answered daily. This one was always published randomly between 9 a.m. and 11 a.m. and expired after 24 hours. If the participant left the questionnaire unanswered within the given time frame, two reminder notifications were sent to fill in the missing answers. One appeared after one hour, whereas the second appears after six hours. Completing the baseline questionnaire took approximately 15 minutes, whereas the daily questionnaire takes 2-5 minutes each time. On the last day of the study, the participants received a final e-mail to thank them for their participation in the study.

Data Analysis

To analyse the data, the statistical program IBM SPSS Statistics 25 was used. Before the data analysis was executed, all data that were collected via Ethica were transformed into SPSS. Participants that did complete less than 50% of the questions were excluded from the analyses (Conner & Lehman, 2012).

With regards to the baseline questionnaire, the demographics age, gender, occupation, nationality and name of video-on-demand streaming services used were analysed through

descriptive statistics. Regarding the daily measurement, the independent variables were the self-reported number of episodes watched and total amount of time watched. Furthermore, the measured dependent variables were the self-reported number of minutes doing light intensity and vigorous intensity activities. Finally, two binge-watching variables were created to analyse the percentage of binge-watching sittings of the sample; one regarding episodes and one regarding the number of hours watched. Thus, two dichotomous variables were created based on the definition of binge-watching. A sitting was coded as binge-watching (coded with 2) when it outperforms the cut-off score of three hours or episodes.

Regarding the baseline questionnaire, the independent variable was Physical Activity, describing if a participant is generally physical active or not. A person was coded as physically active (coded with 1) when fulfilling one of the three criteria: a) minutes of moderate-intensity physical activity in a week is ≥ 150 b) minutes of vigorous-intensity physical activity in a week is ≥ 75 and c) the MET value of a participant within a week is ≥ 600.

The qualitative variables were coded into numeric variables. As a result, the answer to "How many episodes/videos did you watch?" was recoded from N hour(s) into N (e.g. 1 episodes → 1), while "I did not watch" and "I watched a movie" were coded into a 0. Moreover, the items that measured time (e.g. 15 minutes, 1 h, 30-40 min), like questions regarding minutes of moderate-intensity and vigorous-intensity activities were all transformed into a minute number (1h → 60). When intervals were given, an average was taken (30-40 → 35). Moreover, each date of the study was transformed into a time point. Thus, the date 7.04.2020, which was the start date of the study, was coded with zero, while the 20.04.2020, which was the end date of the study, was coded with 12.

With regards to analysing the data, a series of Linear Mixed Models (LMM) with a first-order autoregressive structure (AR1) was applied to the dependent variables of the daily measurements to obtain estimated marginal means for watching behaviour over time and between participants. The specified subject variable was name and the specified repeated variable is day. Answering RQ 1, the dependent variables were the two different kinds of physical activity, the fixed covariate was general physical activity and the fixed effect was physical activity. Regarding RQ 2, the dependent variables were the amount of episodes/hours watched, the fixed covariate and fixed effect was the minutes of light-intensity physical activity variable. Finally, in RQ 3, the dependent variables were the amount of episodes/hours watched, the fixed covariate and fixed effect was the minutes of vigorous-intensity physical activity variable.

Since ESM is a longitudinal study, it was probable that participants may not manage to fill out the questionnaires daily. Thus, LMM was used since these models can account for missing values by estimating numbers for their missing values based on the available data given during the study.

After the Linear Mixed Models were conducted, more participants were excluded for answering the first research question due to various reasons. One participant was excluded because his MET value of 27417.6 was assumed to be too high to be realistic. This assumption was tested by comparing the participants data of the baseline questionnaire with his/hers daily physical activity which in total was less than half of what was reported in the baseline questionnaire. The same reasons for exclusion were applicable for two more participants. Moreover, four participants were excluded due to insufficient information. For example, did they state that they do sports multiple times a week but rarely reported the amount of minutes doing these activities. Another example is that statements were given that could not be transferred into clear numeric data (e.g. I take a 3h walk with my dog every Sunday). Thus, an accurate MET value could not be calculated.

Results

General

On average, participants filled out the questionnaire on 96.78 % of the days. Moreover, the participants had at least access to one streaming service up to a maximum of four streaming services (1 service =2.3%, 2 services =52.3%, 3 services =29.5%, 4 services =15.9%). Apart from that, participants on average indicated that they spent 8 hours and 52 minutes (M= 511.51, SD= 253.58) sitting on a typical day.

Watching Behaviour over the two weeks

Participants indicated that they watched on average 1 hour and 38 minutes daily (M=1.6 hours, SD = 1.6) on video-on-demand streaming with an average number of 1.89 episodes (SD = 2.1). With regards to the number of episodes, only 20.1 % (M=1.2, SD = 0.4) of the sittings met the criterion for binge-watching. Regarding the number of hours, only 12.8% (M=1.13, SD = 0.33) of the sittings were categorized as binge-watching. From this, it can be inferred that the sample did not frequently binge-watch.

Fluctuations over Time.

The average proportion of participants that watched video streaming content daily during the study period was 69.3%. In contrast to that, 30.7% of the participants did not watch video streaming content daily since they had days without watching any episodes.

A Mixed Models analysis was conducted and no significant effect of time on the watching behaviour of the participants was found, neither for episode numbers (estimate= 2.3, F (308.462) =1.618, p=0.85) nor for watching time (estimate = 1.83, F (324.573) =1.055, p= 0.398). Figure 1 illustrates the fluctuations of the data over the course of the 13 days of daily measurements. According to the graph, both average watching time and the number of episodes did vary quite a lot over the days.

During the study period, participants watched 1.89 episodes per day on average. On day 12, the amount of episodes peaked with 2.3 episodes. On day 5, the least amount of episodes was watched with a mean of 1.3 episodes. Since the questions were asked retrospectively, one needs to look at the day before to investigate reasons for the peaks and lows. Since the peak was reached on a Sunday, it might explain the peak amount of episodes. Day 5 was Easter Sunday which might be a reason the low amount of episodes watched since many participants might have been busy doing other social activities regarded to that holiday.

Moreover, an average of 1 hour and 38 minutes was watched per day (M=1.6) over the period. On day 6, the peak amount of watch time was reached with 1 hour and 56 minutes (M=1.9). The least amount of time was watched on day 9 with an average amount of 1 hour and 20 minutes (M=1.2). A reason for the peak could be that Day 6 was Easter Monday which is why many people do not have to work/study. For the low point of Day 9 no obvious reason could be found.

Pearson's correlation was conducted and a strong significant correlation between the estimated mean daily watching time (in hours) and episode number was found ($r = .89$, $p < .05$). This indicates that, as expected, as the daily watching time increased the number of episodes increased as well.

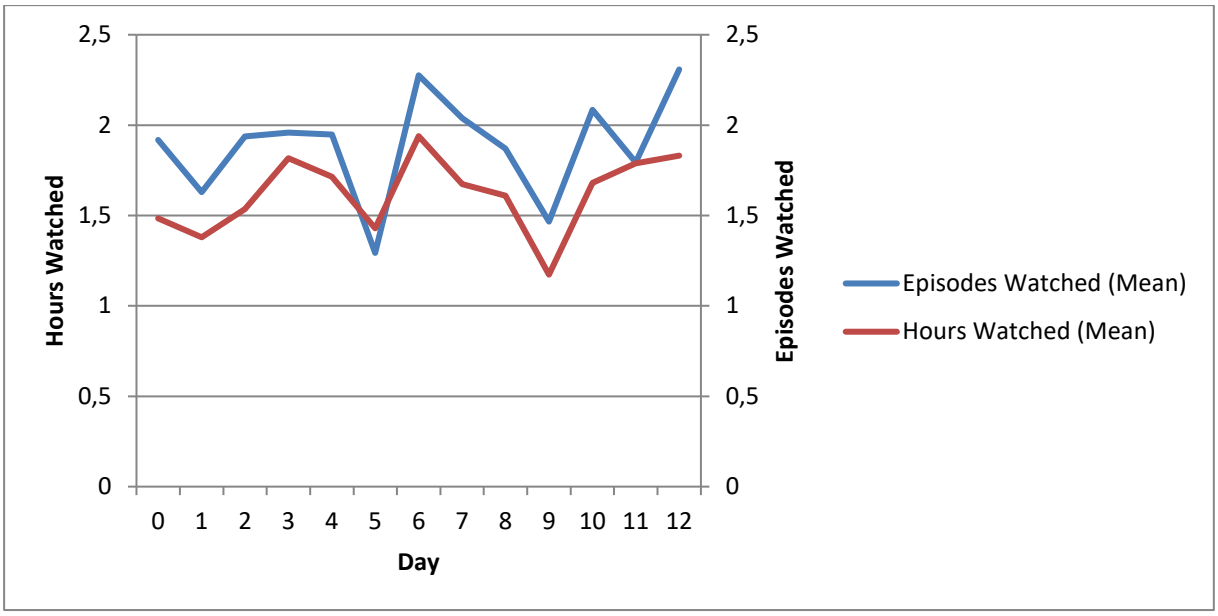

Figure 1. Mean estimated watch time (episodes and hours) over a period of 13 days.

Watching Behaviour

Inter-Individual Differences.

A Mixed Models analysis was conducted and a significant effect of participant on the watching behaviour was found for episode numbers ($p < .05$) and for watch time ($p < .05$).

This indicates that watching time significantly varies per participant. Figure 2 illustrates the mean estimated watch time per participant over the course of the 13 days of daily measurements. According to the graph; both the watching-time and the number of episodes are analogous to each other, reflecting different values for every participant, while maintaining the mentioned correlation.

During the study period, participants watched 0.9 episodes on average. Participant number 11 reported the highest mean of watched episodes (5.4 episodes per day), whereas participant 20 has the lowest mean with 0 watched episodes.

Moreover, an average of 1 hour 1 minute was watched (M=1) over the period. Again, participant number 11 reached has reported the highest mean of hours watched with 5 hours and 3 minutes (M=5.1), whereas participant number 20 demonstrated the lowest mean with 8 minutes of watching (M=0.1).

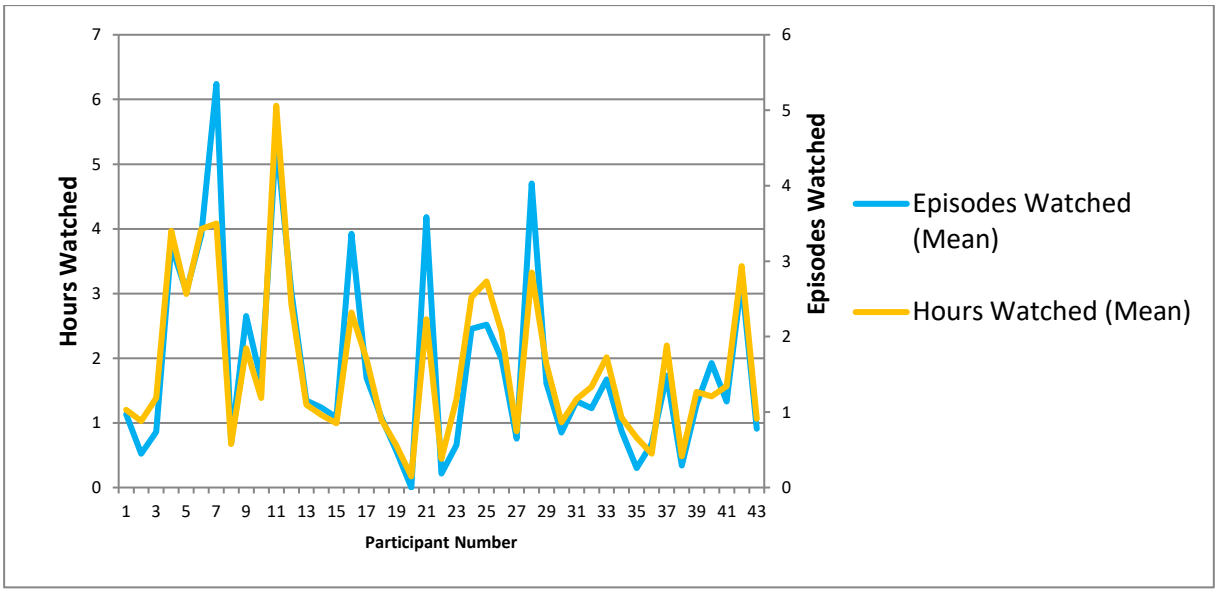

Figure 2. Mean estimated watch time (episodes and hours) over a period of 13 days per participant.

Physical Activity

General Physical Activity.

In total, 74.3% of the participants were categorized as generally physical active based on their statements given in the baseline questionnaire. Therefore, almost 3/4 of the sample fulfilled the WHO recommendations for physical activity.

A Linear Mixed Model was used to explore if physical fitness was associated with daily binge-watching behaviour of the sample group over time. For the association between general physical fitness and daily binge-watching, no significant association was found. Neither the number of episodes (estimate = 4.32, F (92.209=0.393, p=0.532) nor the daily watching time (estimate = 2.63, F (105.754 =0.403, p =0.527) were significantly associated with general physical activity level.

Daily physical activity.

A Linear Mixed Models analysis was conducted for episode number on both types of physical activity and of watching time on both types of physical activity. No significant association was found between the number of episodes and the daily time spent and light-intensity activity (F(459.243) =2,398, p = 0.122) or vigorous-intensity activity (F(393.255)=0.537, p = 0.464). This was also observed for the association of watching time with light-physical activity (F(507.496)=1.880, p = 0.171) and vigorous-intensity activity

(F(462.522)=0.673, p = 0.413). Figure 3 illustrates the mean estimated physical activity (light- and vigorous-intensity) over a period of 13 days.

On day 11, light-intensity activities reached their peak with approximately 58 minutes (M=57.8), whereas the lowest point was on day 6 with approximately 27 minutes (M=26.9) on average. The day before was a Saturday where many people do not have to work/attend (online) lectures. Thus, it could be a reason for participants to take a walk. Day 5 on the other hand was Easter Monday, which is why participants might have spent the day with their family at home.

With regards to vigorous-physical activity, the highest mean was reached on day 4 with approximately 26 minutes (M=26.4), whereas the lowest point was on day 9 with approximately 14 minutes (M=13.5). Day 3 was a Saturday which is most likely a day where many people might have found the time to become vigorously active. A reason for the low amount of vigorous-activity is not clear, except the fact that day 8 was a Thursday on which many people have to work/study.

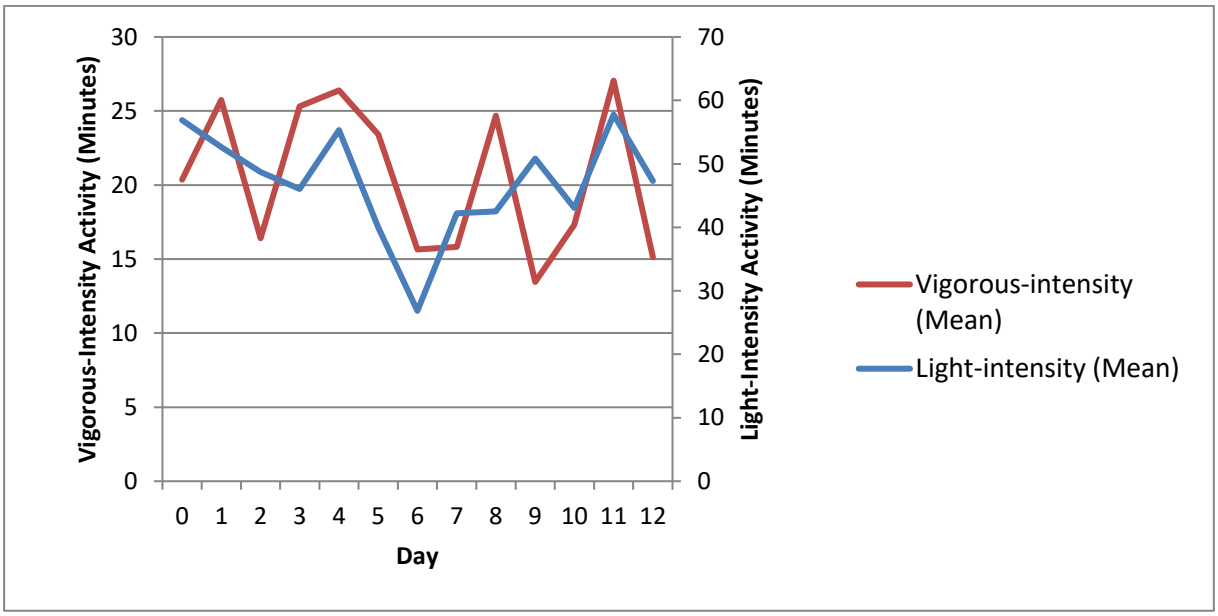

Figure 3. Mean estimated physical activity (light- and vigorous-intensity) over a period of 13 days.

Inter-Individual Differences.

When comparing the different participants with each other, inter-individual differences can be found. According to the graph (Fig. 4), the general physical activity of participants was between 0 and 70 minutes of physical activity. As expected, the graph shows

that light-intensity activities were executed for a longer amount of time than vigorous-intensity activities.

This can also be seen when comparing the participants' mean time between the two different kinds of physical activity. The participants average number of daily light physical activity was 46.51 minutes (SD = 68.02) with a minimum of 0 and a maximum of 600 minutes. With regards to vigorous physical activity, the mean amount of minutes of the participants is 20.49 minutes (SD=33.59) with a minimum of 0 and a maximum of 300 minutes. Comparing the participants watching behaviour with their physical activity, the lack of association between both variables can be seen (Fig. 5).

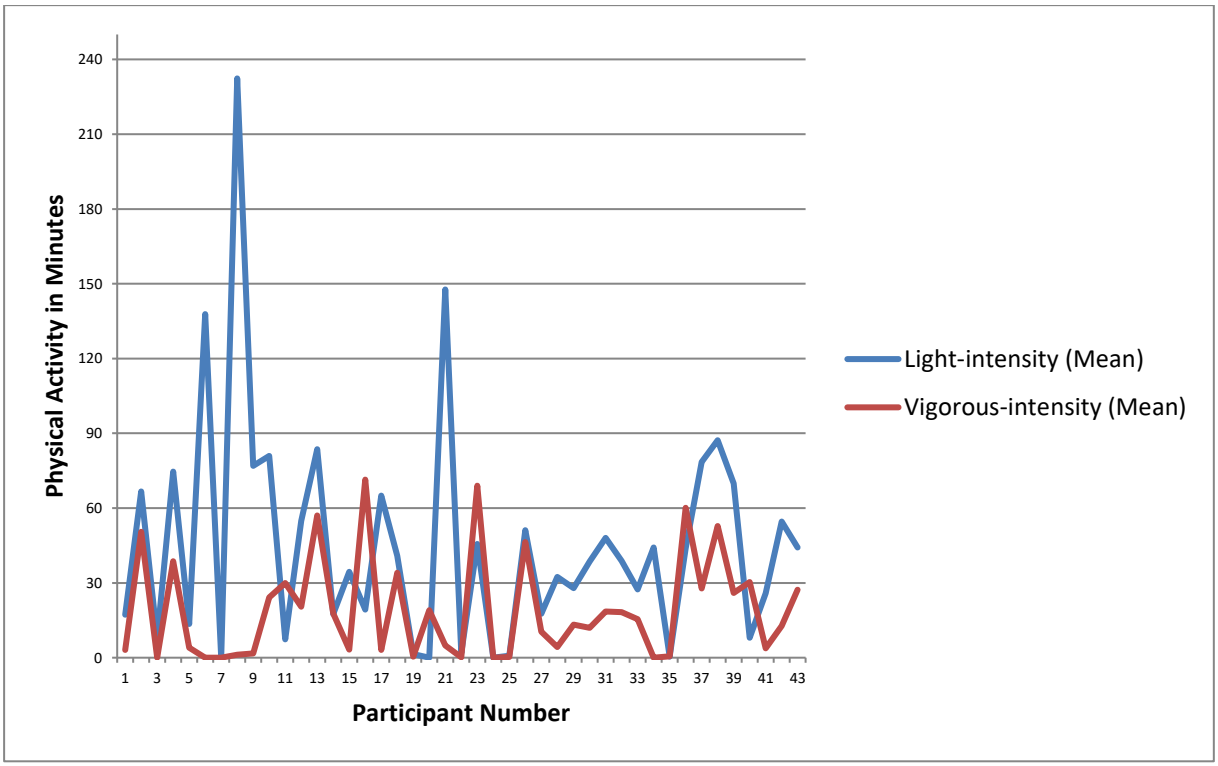

Figure 4. Mean physical activity (light- and vigorous-intensity) over a period of 13 days per participant.

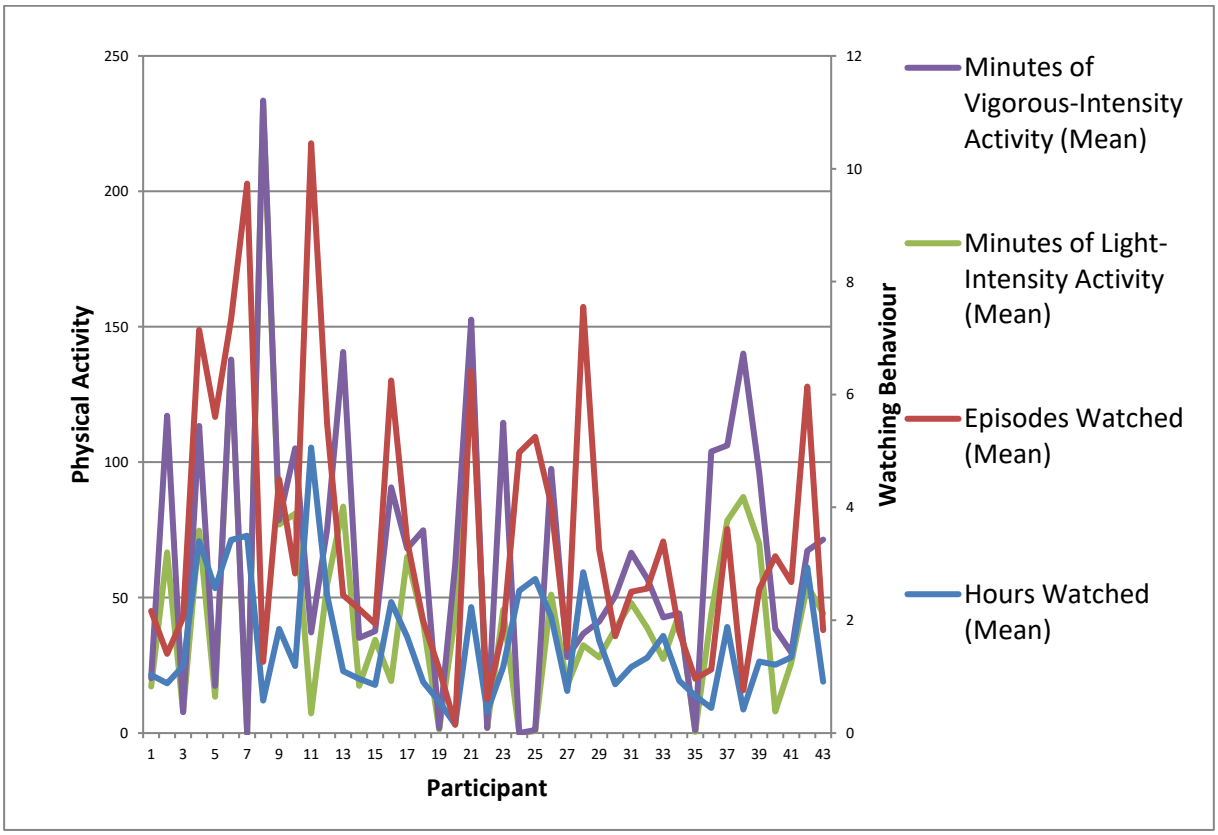

Figure 5. Watching behaviour and physical activity over a period of 13 days per participant.

Discussion

Binge-watching is considered as predominant sedentary behaviour. Thus, it was investigated if video-on-demand watching is related to the general and daily physical activity of participants. In this study, two-thirds of the self-reported binge-watchers in the sample fulfilled the WHO recommendations for physical activity and are thus, generally physical active people. Nevertheless, no significant association between general physical fitness and watching behaviour was found. Moreover, no significant association was found for daily watching behaviour and physical activity over time, neither for light-intensity activity nor for vigorous-intensity activity.

Overall, the results of this study suggest that video-on-demand watching was not associated with the amount of physical activity, neither light-intensity nor vigorous-intensity, that binge-watchers performed daily. Nevertheless, the current study does indicate that both watching behaviour and physical activity significantly varies per participant. Hence, there must be other reasons why people engage or do not engage in physical activities. As other studies have already shown, factors like motivation, social interaction, health reasons and physical appearance are, amongst others, reasons for engaging in physical activity (Ríos, Cubedo, & Ríos, 2013).

Since this field is relatively new, there is only a little literature that deals with the connection between binge-watching and physical activity. Still, the study by Spruance et al. (2017), mentioned in the introduction, showed that the more time people spend in front of the TV, the less time they spend on physical activity. Additionally, it was stated that non-binge watchers are more likely to meet the physical activity recommendations than binge-watchers. Both findings could not be replicated by this experience-sampling study. The governmental regulations regarding Covid-19 during the time of data collection may be responsible for that. The closure of gyms, for example, might have deterred participants to exercise as usual. Moreover, light-physical activities that are fixed components of the daily routine, such as riding the bike to university or walking to work, were often cancelled since home office was widespread during that time. A too homogenous sample, amongst other factors, could be another reason.

Even though this present study did not show a significant association between video-on-demand watching and physical activity, this does not necessarily mean that VoD-watching has no negative health consequences. Previous studies found a link between binge-watching and sleeping quality and also healthy diet correlated with binge-watching (Flayelle, 2020).

Therefore, it can be presumed that binge-watching has potential negative health consequences other than general and daily physical activity.

With regards to the number of episodes, only 20.1 % (M=1.2, SD = 0.4) of the sittings met the criterion for binge-watching. Regarding the number of hours, only 12.8% (M=1.13, SD = 0.33) of the sittings were categorized as binge-watching. From this, it can be inferred that the sample did not frequently binge-watch.

The lack of a clear definition to measure the relatively new concept of binge-watching is a challenge within research. This is why this study only analysed the number of episodes and hours watched as continuous measures instead of strictly analysing binge-watching. Moreover, this study measures physical activity subjectively since the participants answer the questions themselves. As mentioned in the study by Kanning (2013), the subjective measurement of physical activity does not correlate well with the objective measurement. Thus, technical devices that measure physical activity objectively (e.g. accelerometer or step-counter integrated into the phone) would give more reliable correlations. Additionally, the shortage of scientific studies in this field regarding the health consequences of binge-watching makes it difficult to formulate clear hypotheses. Hence, this study focused on exploring the association of VoD-watching with physical activity instead of testing hypotheses.

Nevertheless, this study investigating the connection to physical health adds to current literature, because in the past, mainly mental health has been investigated with regards to binge-watching. Apart from that, the experience-sampling method has barely been used in past studies regarding binge-watching although it shows major advantages over cross-sectional survey designs.

This method appeared to be useful in a lot of ways. Since the participants were able to stay in their natural environment, the distortion of data was minimized. Moreover, this method allowed for more detailed clues about temporal associations over time which was necessary to answer the research questions. Additionally, memory bias was minimized due to the immediate daily retrospective questionnaire the next day. Finally, ESM was useful to get a detailed insight into the fluctuations over time and the inter-individual differences. On that note, this study is a contribution to current studies because it adds data that is gathered in an effective, yet too little used, way.

Generally, measuring the construct of binge-watching is difficult due to the approximately 20 different definitions used in previous research (Flayelle et al., 2020). Therefore, this study can be criticized for merely measuring the amount of watched episodes and the number of hours watched instead of creating a cut-off score that enables the more

specific measurement of the construct. Consequently, the study does not precisely measure binge-watching itself but the video-on-demand watching behaviour. Additionally, most sittings within the study period could not be categorized as binge-watching based on the definition used in this study. Finally, the association between VoD-watching and physical activity may be non-linear which is not tested by this ESM study. ESM study.

Another critical point of this study is the composition of the sample. The sample consisted of way more females than males, making the sample more homogenous. Additionally, more than half of the participants were students even though this was not the specifically stated target group. Moreover, the study only consisted of five different nationalities although Germany constituted almost 85% of the sample.

The consequences of the specific sample characteristics could be the following: As the biggest proportion of the sample consists of students, it can be assumed that it represents rather educated people. Therefore, the sample might be educated about the health consequences of too less exercise and prolonged sitting already and is therefore not representative of the whole population. Furthermore, the sample probably consists of well-behaved and controlled people since the sittings were seldom considered as binge-watching. Therefore, it can be assumed that the association between binge-watching/ VoD-watching and physical activity might be different when having a sample that is representative of the "at-risk" population.

The most notable limitation was the specific period of the data collection. Due to Covid-19, governmental restrictions and regulations have been agreed on worldwide, including the closure of gyms and sports clubs. For example, in Germany, where the biggest percentage of the participants comes from, gyms and sports clubs were closed from mid-march on. Thus, many participants could not do their exercise in the way they were used to. This would also explain why the majority of the participants was categorized as physically active, but still did not execute vigorous-intensity activities during the study period regularly. Besides that, the participants that would usually go to university or their job could now work from home, reducing their daily light-intensity activities. All these factors may have influenced the study results since it was conducted within a pandemic that led to extraordinary circumstances which do not represent their usual activity patterns.

The preliminary condition that most people could not work/study from home had also an advantage for this study and may have resulted in the high observed response rate. Especially within the experience sampling method, having a high response rate is crucial to gather reliable data. In a systematic review, it was found out that the average response rate

within ESM studies with mobile devices is 69.6%, whereas this present study showed a response rate of 96.78% of the days (Berkel, Ferreira, & Kostakos, 2018).This could also be explained by the fact that this study used one measurement per day instead of multiple ones, increasing the likelihood of answering the questionnaires.

Besides a high response rate, the experience sampling method minimized the memory bias since the questions regarding physical activity and binge-watching behaviour are asked in the morning on the next day and was available for 24 hours. A memory bias was, therefore, less likely to be present since the questions did not regard any mental states known as the "memory-experience gap" (Ellison, et al., 2020).

Finally, the experience-sampling method itself has major advantages. Since data was gathered by a smartphone application, the participants could stay in their natural environment during the whole study period, increasing the ecological validity of the results. Moreover, reliability and validity are increased due to the reduced assessment error. Besides that, the ESM method can provide clues about the temporal associations of the variables of interest over time which was could not be examined in previous cross-sectional surveys with regards to binge-watching. Apart from that, this method gave more insight into the within-subject effect which was important for this study to examine the variability of binge-watching for the individuals within the sample.

Future Research and Conclusion.

The results of the study show that either the amount of watching VOD services is not related to physical activity or that the study needs to be improved. One suggestion is to choose a more diverse sample that includes more males, more non-students, a more diverse age range and socioeconomic status and people from different countries all around the world. Secondly, it should be tested if a non-linear relationship exists between VoD-watching and physical activity since this study only investigated the existence of a linear relationship. Finally, the measurement of the binge-watching construct needs to be improved. In what way this can be implemented cannot be stated for now but the more research regarding this topic is done, the easier it might be to find a suitable way of measurement. An idea is to create a valid cut-off score for binge-watching based on an established definition on binge-watching. Since this definition is not given yet, more exploratory studies and data-driven approaches should be conducted in the future that might lead to a final definition of the construct. Thirdly, replicating this study after the COVID-19 regulations have been loosened is suggested in order to find more representative results.

In sum, several conclusions can be made with regards to this present study. The study aim was to answer the research question if general physical fitness is associated with daily binge-watching and if daily binge-watching over 13 days is significantly associated with light- and vigorous-intensity activities. Overall, it can be concluded that in the current sample there was no significant association between general physical fitness and VoD-watching and VoD-watching and light- and vigorous-physical fitness over 13 days. However, this study faced some challenges that need to be considered when interpreting the results. Therefore, this study should be replicated with the suggested improvements to accurately examine the associations of interest.

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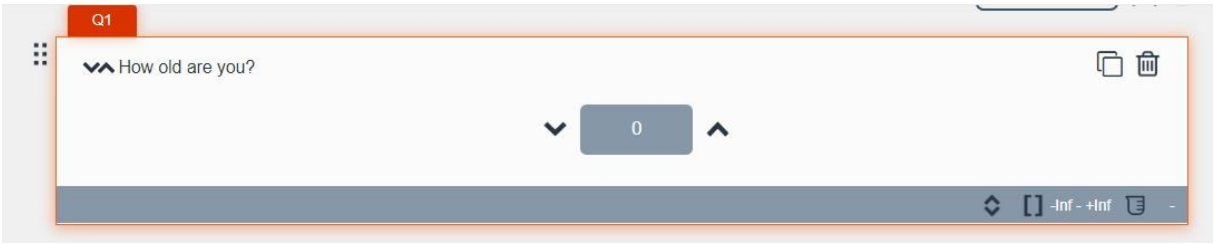
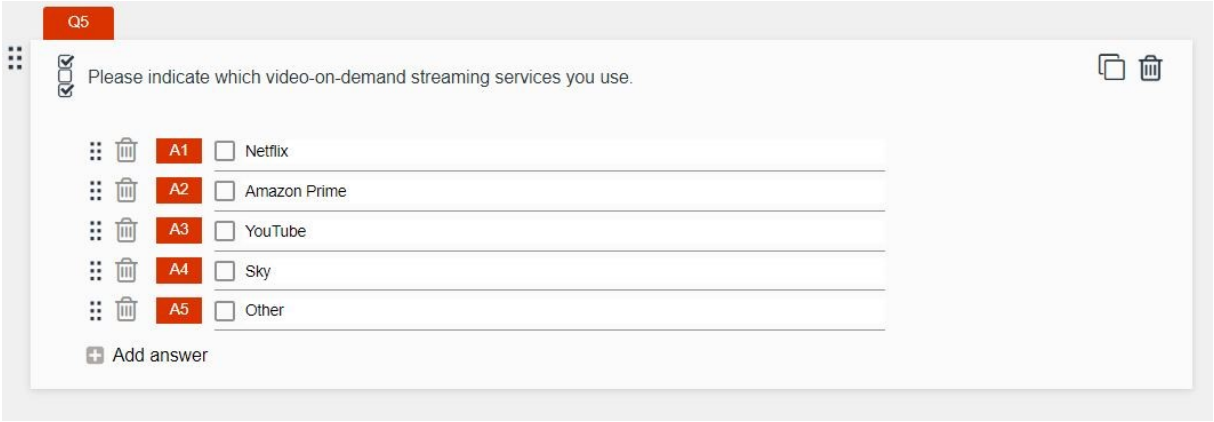
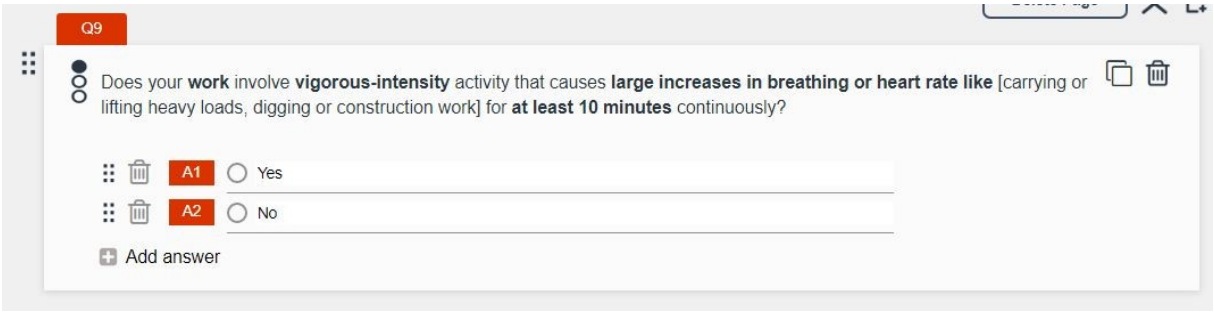
Appendices

Appendix A: Baseline Questionnaire



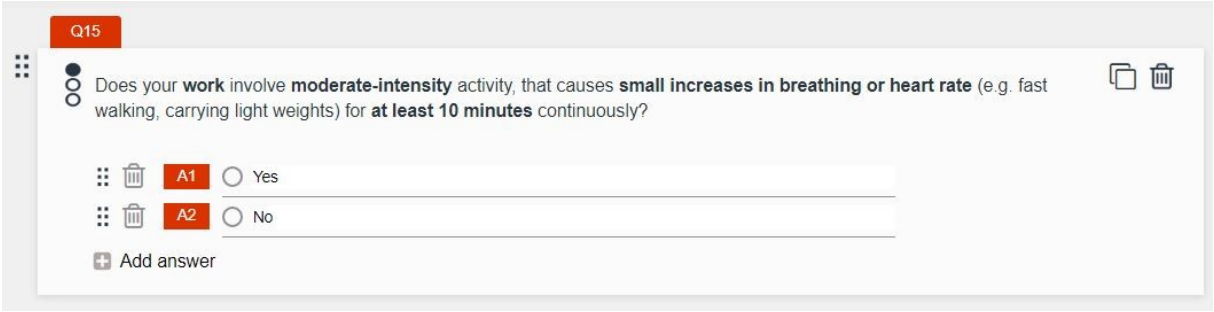

Q4
Please indicate your nationality.


Q5
Please indicate which video-on-demand streaming services you use.
A1 Netflix
A2 Amazon Prime
A3 YouTube
A4 Sky
A5 Other
Add answer

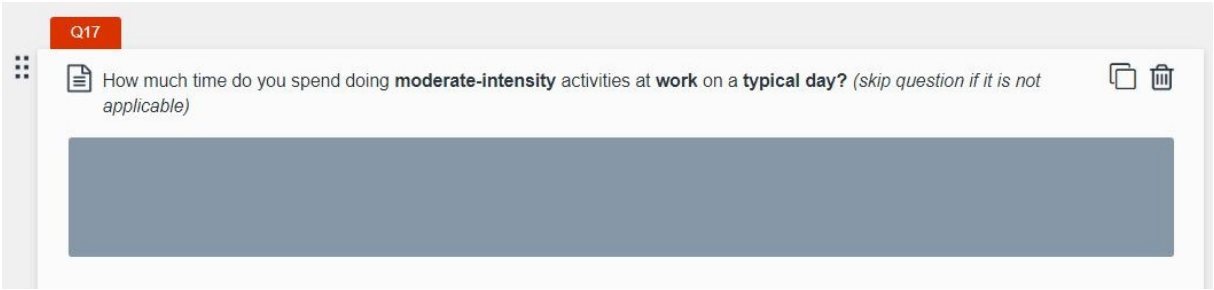

Q9
Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like [carrying or lifting heavy loads, digging or construction work] for at least 10 minutes continuously?
A1 Yes
A2 No
Add answer

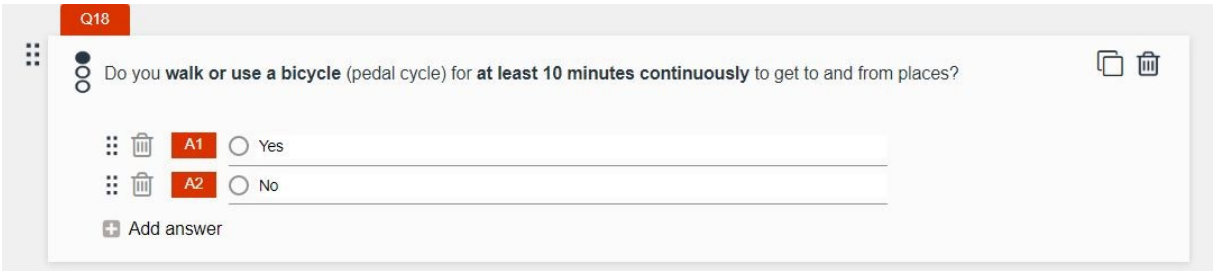

Q11
In a typical week, on how many days do you do vigorous-intensity activities as part of your work?
0
-Inf - +Inf

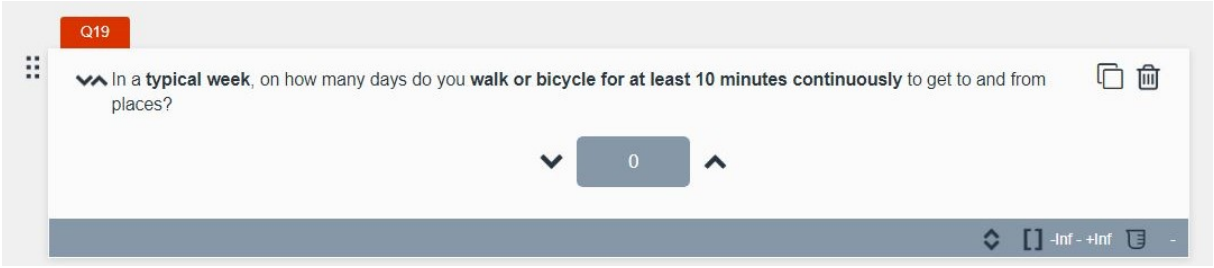

Q12
How much time do you spend doing **vigorous-intensity** activities at **work** on a **typical day**? (in hours and minutes) *(skip question if it is not applicable)*

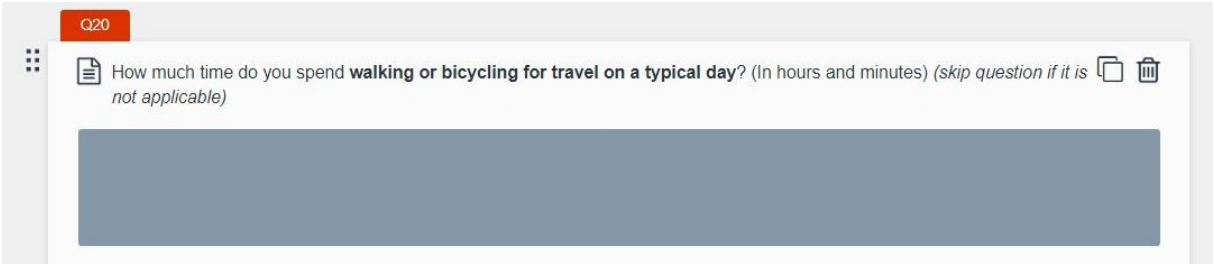

Q15
Does your **work** involve **moderate-intensity** activity, that causes **small increases in breathing or heart rate** (e.g. fast walking, carrying light weights) for **at least 10 minutes** continuously?
A1
Yes
A2
No
Add answer

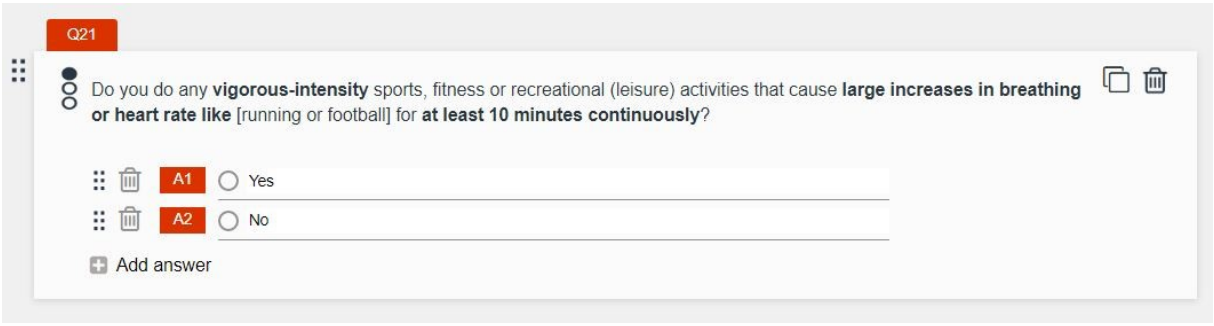

Q16
In a typical week, on how many days do you do **moderate-intensity** activities as part of your **work**?
0
-Inf - +Inf


Q17
How much time do you spend doing **moderate-intensity** activities at **work** on a **typical day?** *(skip question if it is not applicable)*

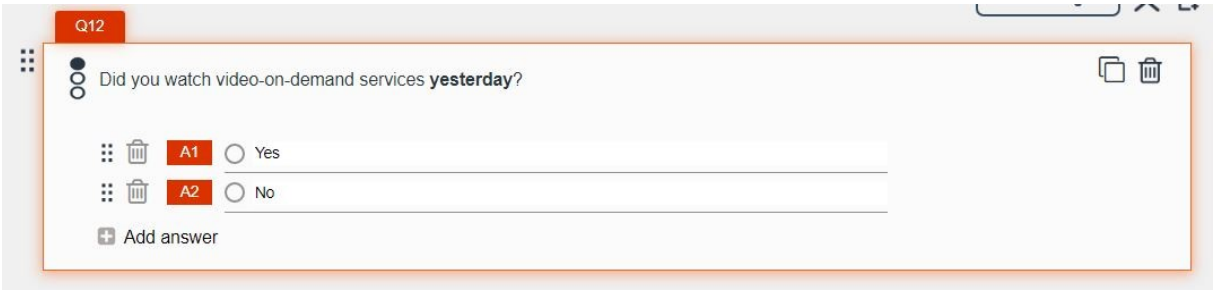

Q18
Do you **walk or use a bicycle** (pedal cycle) for **at least 10 minutes continuously** to get to and from places?
A1
Yes
A2
No
Add answer

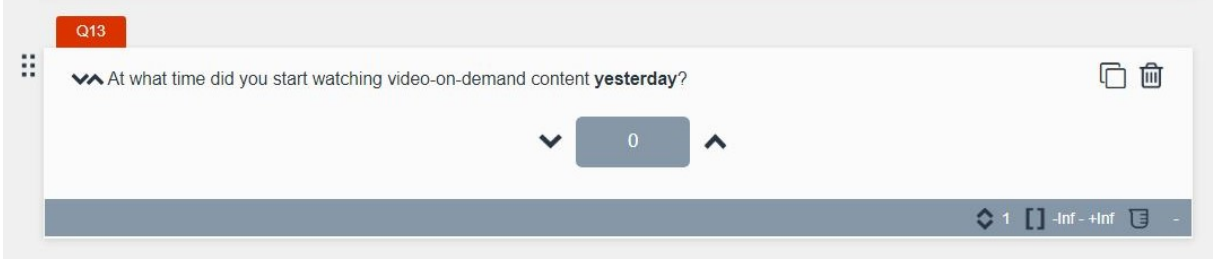


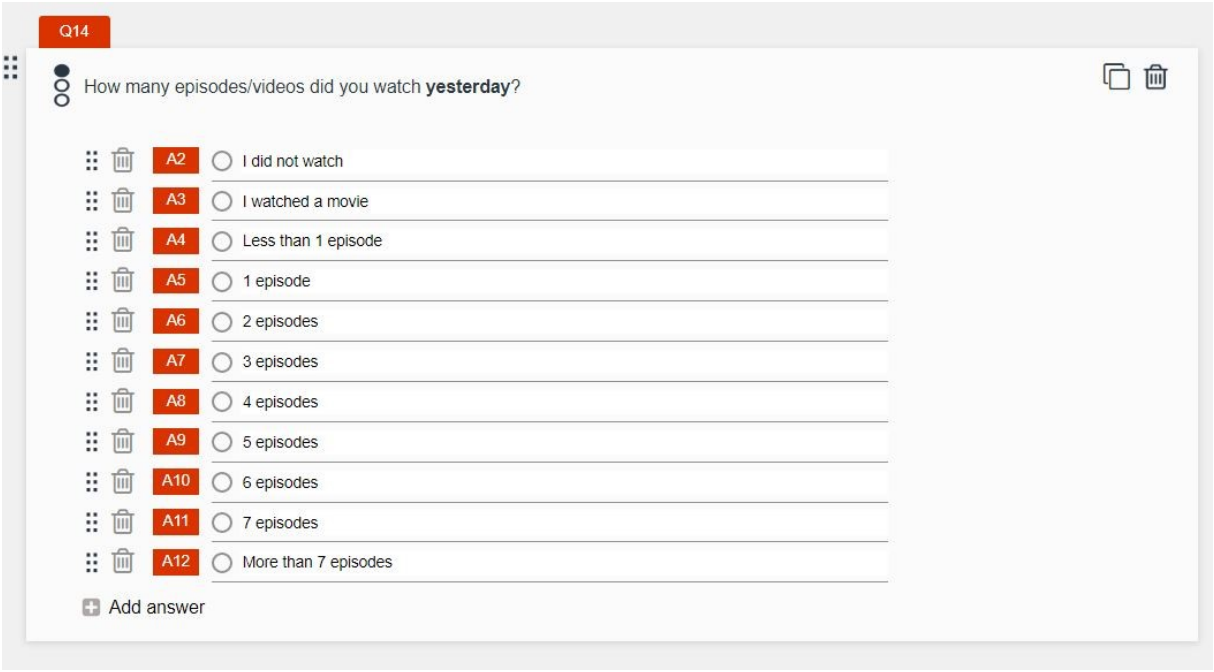


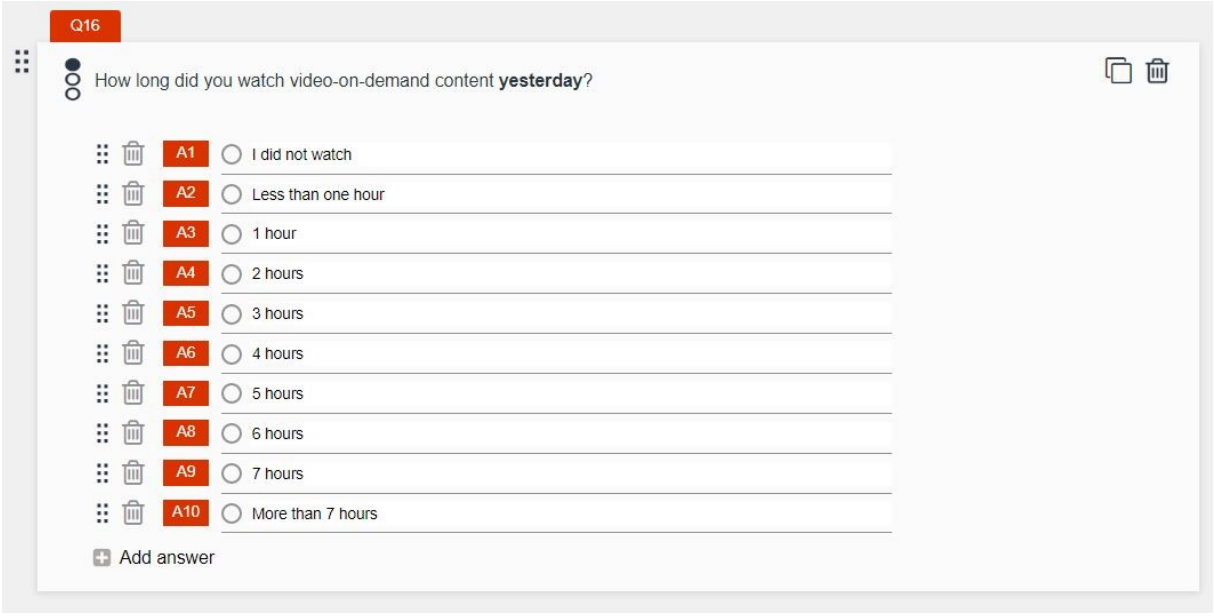


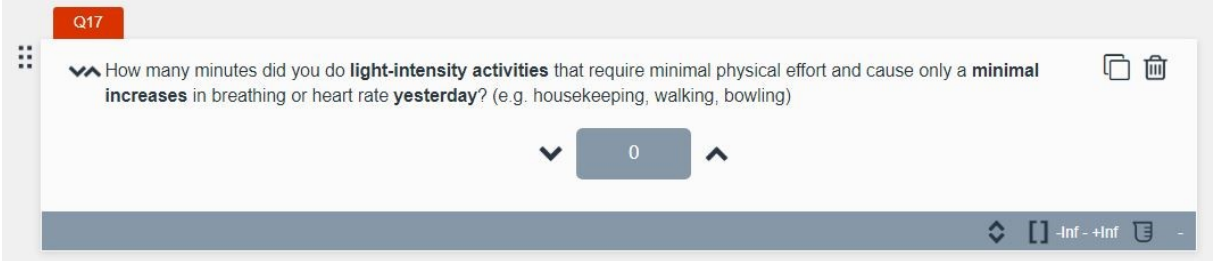
Appendix B: Daily Retrospective Questionnaire

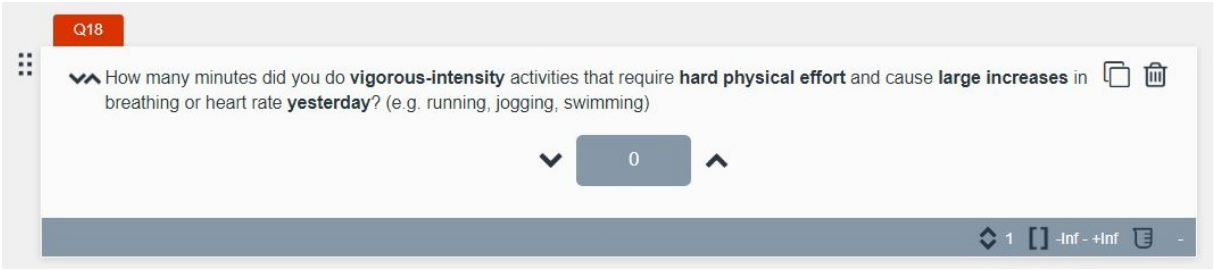





Q14
How many episodes/videos did you watch **yesterday**?
A2 I did not watch
A3 I watched a movie
A4 Less than 1 episode
A5 1 episode
A6 2 episodes
A7 3 episodes
A8 4 episodes
A9 5 episodes
A10 6 episodes
A11 7 episodes
A12 More than 7 episodes
Add answer


Q16
How long did you watch video-on-demand content **yesterday**?
A1 I did not watch
A2 Less than one hour
A3 1 hour
A4 2 hours
A5 3 hours
A6 4 hours
A7 5 hours
A8 6 hours
A9 7 hours
A10 More than 7 hours
Add answer


Q17
How many minutes did you do **light-intensity activities** that require minimal physical effort and cause only a **minimal increases** in breathing or heart rate **yesterday**? (e.g. housekeeping, walking, bowling)
0
-Inf - +Inf


Q18
How many minutes did you do **vigorous-intensity** activities that require **hard physical effort** and cause **large increases** in breathing or heart rate **yesterday**? (e.g. running, jogging, swimming)
0
1
-Inf - +Inf

Appendix C: E-Mail containing the description and information about the study

Dear participant,

We would like to thank you in advance for choosing to be a participant in this study named "Binge-watching: an experience sampling study of video-on-demand watching". The aim of this study is to investigate the relatively new topic of binge-watching and its connection to eating behaviour, physical activity, emotions and personality is investigated. This study starts on **April 7,2020** and ends on **April 21, 2020**. It is emphasized that the time period of the study cannot be postponed. Thus, it is important to start exactly on the **7th of April**. In the following, you will find the steps that need to be completed in order to participate in this study.

How to Start:

Within the next 2 weeks, you need to complete different questionnaires. The questionnaire on day 1 is a more detailed one, compared to the following days, and takes therefore 15 minutes. It is important to fill out this questionnaire on **April 7, 2020** because it will assess some baseline information like age, gender and personality that is needed for this study. You will have the whole day for this. From day 2 to day 15, the questionnaires are shorter but need to be completed multiple times a day.

- between 9 a.m. and 11 a.m. (max. 2 minutes)

-between 9 a.m. and 11 a.m. (max. 5 minutes)

- between 2 p.m. and 4 p.m. (max. 2 minutes)

- between 7 p.m. and 9 p.m. (max. 2 minutes)

The questionnaires are provided via the app **Ethica**. We ask you to complete the questionnaires as soon as you receive the notification. In case you won't complete it immediately, you will receive a reminder to complete the questionnaire. If you do not fill out the questionnaire in time, it will expire shortly after. In this case, you should continue with the upcoming questionnaires as usual. You are asked to click on the download-link below and download the app in the appstore or gamestore. The app can be downloaded for **free**. In addition to this e-mail you will also receive an e-mail from Ethica. In this e-mail you can find the registration code that is needed to register in this particular study.

Step 1: Download the app (download links are listed below) to create an account. Thus, you are asked to enter your e-mail address and to choose a password. Please register as a participant.

- ➔ Itunes App Store: https://apps.apple.com/us/app/ethica/id1137173052
- ➔ Google Play Store: https://play.google.com/store/apps/details?id=com.ethica.logger&gl=NL

Step 2: Open the app.

Step 3: Log-in with your account using your e-mail address and password.

Step 4: Enter the registration code that can be found in the e-mail from Ethica.

Step 5: If you agree with the consent form please click on register.

Step 6: Turn-on the **notifications** for this app since the app will send you reminders to not miss out on any questionnaires and thus, make your data useful for the study.

Please register **before the 7th of April 2020** in case any problems or questions regarding the study arise. The first questionnaire should appear on **April 7**, 2020 at **9 a.m.** If this is not the case, please contact us immediately. The questionnaires will take you max. 15 minutes daily. Please check your phone around the time frames that were mentioned above in order to successfully participate in this study.

The contact information can be found below in case problems/questions arise.

Alisa Acar – a.acar-1@student.utwente.nl

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Mara Wischmann – m.wischmann@student.utwente.nl

Kind regards,
Alisa Acar, Aline Feldkamp & Mara Wischmann