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ORIGINAL ARTICLE

Muskuloskeletal

Physical activity in Norwegian teenagers and young adults with haemophilia A compared to general population peers

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Abstract

Introduction: Limited evidence exists on objectively measured habitual physical activity (PA) of young people with haemophilia (PWH).

Aims: To compare different outcomes of objective PA between young PWH A and controls using a commercial activity tracker.

Methods: We enrolled males aged 13–30 years with moderate and severe haemophilia A, without inhibitors on regular prophylaxis. PA was measured with the activity tracker Fitbit Charge 3 for 12 weeks. Control group data was obtained from ≈60,000 Fitbit users, matched on age, sex and measurement period. PA variables [steps, intensities, volume, activity types, exercise frequencies and proportion meeting the World Health Organization's moderate-to-vigorous PA (MVPA) recommendations] were compared between groups descriptively and using Welch's two-sample t-test and two-sample test of proportions.

Results: Forty PWH A were enrolled (mean age 19.5 years, 50% teenagers, 50% adults, three (7.5%) with moderate and 37 (92.5%) with severe haemophilia). Mean daily steps and minutes MVPA were similar between PWH and controls. PWH spent more time in light PA (mean 227 vs. 192 min/day, $P = .033$) and exercised more frequently (mean 5.6 vs. 3.9 exercise sessions/week, $P < .001$). Among teenagers, 40% PWH and 8% controls reached MVPA recommendations, compared to 95% and 100% among adults. The most common type of PA was walking.

Conclusion: This cohort of young PWH A on prophylactic treatment had PA levels comparable to controls. Still, a considerable proportion of teenagers did not meet the recommended weekly volume of MVPA, and we encourage clinicians to have a particular focus on promoting PA for this group.

KEYWORDS
exercise, Fitbit, haemophilia, haemophilia A, physical activity

1 | INTRODUCTION

With the availability of clotting factor concentrates and individualised prophylaxis, most people with haemophilia (PWH) in developed countries now have the possibility to live physically active lives with only a minimal risk of bleeds.[1] Nowadays, PWH are encouraged to participate in regular physical activity (PA),[2,3] in line with World Health Organization (WHO) recommendations.[4] A physically active lifestyle can contribute to improved physical and mental health,[4] and research indicate that regular PA may lead to a reduction in bleeds and improvements in joint, bone and muscle status for PWH.[2,5,6]

Most previous studies investigating PA in PWH used self-report instruments like questionnaires and activity diaries. Such subjective methods are simple and inexpensive, however, objective measurement methods are usually recommended to reduce bias[7]; the use of an activity tracker is one such option.[8] There is no single device that captures all components of PA,[9] and all activity trackers have strengths and weaknesses.[10] Therefore, factors such as accuracy, cost, user-friendliness, wear-compliance, and participant preferences should be considered in the choice of device.[9,11] Fitbit is one of the world's largest and most popular wearable device companies,[12] and their devices are frequently utilised by researchers and general consumers.[13] Furthermore, the Fitbit Charge HR model has been found suitable for measuring PA in adult PWH over longer time periods.[14,15] Recently, we investigated the accuracy of the Fitbit Charge 3 among PWH. We found moderate to high correlations between Fitbit and ActiGraph GT3X measured daily averages for all PA variables, but the Fitbit tended to overestimate steps and minutes in light and vigorous intensity PA.[16] However, the ActiGraph is not a criterion measure for PA measurement, and its limitations include that is does not capture non-ambulatory activities well, and inability to capture the extra energy expenditure associated with for example carrying loads or walking uphill.[10] Furthermore, wear-compliance is often lower for hip-worn than wrist-worn devices.[9] Hence, it may be that wrist-worn multi-sensor activity trackers (such as Fitbit) can provide better PA estimates, especially if participants perform a lot of non-ambulatory PA (e.g. strength training, yoga).[10,17]

A few studies have investigated habitual PA of PWH via objective methods, with measurement periods of one week.[18–21] Results from such a short period is possibly not representative of participants' habitual PA, as people might alter their behaviour when they know they are being monitored, and because PA levels tend to vary from week to week and with seasons.[22,23]

The aim of our study was to compare objective PA [steps, intensities, volume, activity types, exercise frequencies and proportion meeting WHO recommendations for weekly moderate-to-vigorous PA (MVPA)] in young PWH A to controls, measured by an activity tracker over a 12-week measurement period. Furthermore, we aimed to investigate whether PA levels of PWH changed over the measurement period.

2 | METHODS

2.1 | Ethical considerations

This study was preregistered at ClinicalTrials.gov (NCT04181697). Ethical approval was granted by the Regional Committee for Medical and Health Research Ethics South East and the Oslo University Hospital (OUH) Data protection officer. All PWH (and/or their guardians) provided written informed consent prior to study participation. For the general population control group, all Fitbit users consent that Fitbit may store and share aggregated and de-identified non-personal information to third parties.

2.2 | Participant recruitment

We included PWH aged 13–30 years, diagnosed with moderate or severe haemophilia A (factor VIII activity < 5 international units (IU)/dL),[24] without inhibitors and on continuous prophylaxis. PWH were not eligible if they were unable to wear a Fitbit for the time corresponding to the duration of their usual school- or workday. The OUH Haemophilia Comprehensive Care Centre (HCCC) treats all PWH in Norway, including children, teenagers, and adults. There are 349 PWH A in Norway.[25] Potential study participants were identified from the OUH HCCC's national registry of people with bleeding disorders. At the start of the study, 55 PWH in the registry were identified as eligible (Figure 1). Participants were recruited consecutively in connection with their annual follow-up appointments or asked to come to the centre for a separate study visit. The target sample size (n = 40) was based upon feasibility of recruitment considering the low number of eligible patients (n = 55).

2.3 | Procedures

At study visit, PWH were provided with a Fitbit Charge 3 (Fitbit Inc, San Francisco, California, USA) activity tracker to be worn on the non-dominant wrist. The home screen (called 'clock face') of the device was set to show time and date only. Default reminders to move were turned off and PA goals were set to the maximum to avoid prompts and 'rewards' that could potentially influence habitual PA behaviour. Proper use of the device was demonstrated and an instruction sheet including information regarding charging and synchronising was provided. PWH were instructed not to change any device settings and to wear the Fitbit during all waking hours. We created Fitbit study accounts for each person and set up the devices based on participants' sex, age, height, body weight and hand dominance. The Fitbit app was installed on the participant's (or guardian's) smartphone and connected to the Fitbit device to enable data synchronisation. Study user accounts were connected to the research platform 'Fitabase' (Small Steps Lab, San Diego, California, USA), and a measurement period of 12 weeks

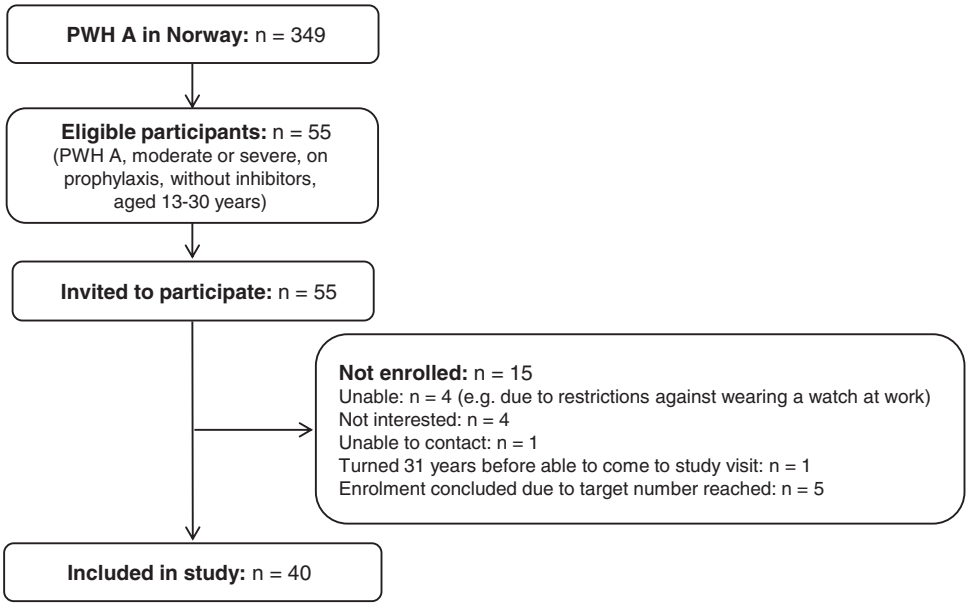

FIGURE 1 Flow chart for PWH

(84 days) from study inclusion was set. PA data were collected between October 2019 and August 2020.

2.4 | Physical activity variables measured

We collected data on number of steps and minutes in light- (LPA), moderate- (MPA) and vigorous intensity (VPA) PA, as well as activity types and exercise sessions. An 'exercise session' was defined as what had been registered as a 'workout' by the Fitbit. Such sessions can be started manually via the device, or auto detected. The Fitbit can recognise and record 'high-movement activities' (called exercise or a 'workout') automatically through a feature called 'SmartTrack'. This is by default set to recognise seven activities (walking, running, 'aerobic workout', elliptical, outdoor bike, 'sports', swimming) of at least 15 min duration.[26] Data were accessed from Fitabase. Thresholds for Fitbit PA intensity categories are based on metabolic equivalent of tasks (METs), which is an estimate for absolute rate of energy expenditure, described as a multiple of resting energy expenditure.[27] The algorithm from which intensity categories are converted to corresponding MET values is unknown outside the Fitbit Company. We included only valid measurement days in our analyses, defined as a day with > 1000 steps. This was based on the findings of Carrasco et al.[14] where a day with a step count < 1000 was reported by PWH to be atypical, and that a step count below this has been found uncommon also in the young general population.[28] Furthermore, this criterion for a valid day has been adopted in previous research using Fitbit devices,[29–31] and very good agreement (98.9%) between valid day definitions based on a step count > 1000 versus wear-time derived from heart rate readings has been found also outside the haemophilia population.[32]

2.5 | Covariates

Demographical, medical and treatment information was extracted from electronic patient records. Body weight, height and waist circumference was measured and index joint (elbows, knees and ankles) status evaluated at study visit, using the 'Haemophilia Joint Health Score' (HJHS) 2.1[33] and 'Hemophilia Early Arthropathy Detection with Ultrasound' (HEAD-US).[34] Lower scores equal better joint status for both tests.[33,34] HJHS was performed by trained physiotherapists affiliated with the HCCC, and ultrasound by haematologists who had undergone HEAD-US preceptorship. Body mass index (BMI) was calculated by dividing body weight in kilograms (kg) by height in meters (m) squared ($BMI = kg/m^2$).

2.6 | Control group data

Control group data for Norwegian general population Fitbit users were extracted from the Fitbit corporation research database based on ≈60,000 users. According to the PWH characteristics, data from male Fitbit users aged 13–30 years (information entered by controls when creating Fitbit accounts) recorded in the same period as the current study's measurement period (October 2019 to August 2020) was downloaded. Control group device settings are unknown. The choice of the widely used Fitbit as PA measurement device for this study made it possible to obtain data for a large general population control group. The control data consisted of the whole population of male Fitbit users in Norway aged 13–30 years. To maintain anonymity of the controls, we received aggregated data for two-year age groups (e.g. age groups of 13–14 years, 15–16 years, etc.) and calendar weeks. For each group, we received means and standard deviations (SDs) of steps,

minutes in LPA, MPA, VPA, BMI and number of weekly exercise sessions and proportions that exercised at least once, twice or three times per week. Activity type data were provided in proportions that performed selected activities at least once per week. We received data for valid measurement days only, defined as > 1000 steps/day. Since we did not receive the actual age of the controls, the group's mean age could not be calculated and compared to the patient group.

2.7 | Statistical analysis

Analyses were conducted using Stata version 17.0 (StataCorp LLC, College Station, Texas, USA). We calculated the variable 'MVPA' by summarising MPA and VPA, and 'total PA' by summarising LPA, MPA and VPA. To match control data, we calculated the proportions of PWH that exercised at least once, twice or three times per week and proportions that performed selected activities at least once per week. For the variables: steps, LPA, MPA, VPA, MVPA and total PA, we calculated one aggregated daily average over the 12-week period for the PWH and one aggregated daily average over all age- and week groups for the controls. Control group means and SDs were aggregated using the formula from the Cochrane Handbook for Systematic Reviews of Interventions.[35] This approach was chosen to account for day-to-day variability in PA outcomes, and thereby get a robust estimate of the participants' daily PA levels for the complete measurement period. Furthermore, because it is PA levels over an extended period that is important to health (PA lifestyle), the daily average of MVPA was used to create the weekly overall average of MVPA, which was calculated by multiplying the aggregated daily average MVPA by seven for PWH and controls. This variable was subsequently used to create the binary variable 'meeting weekly WHO PA recommendations'; for teenagers this was defined as ≥420 min/week and for adults as ≥150 min/week of MVPA respectively.[4] Additionally, to get an idea of the average and variability of number of weeks where PA recommendations were met for PWH, we calculated the number and percentage of weeks (out of 12) where PWH met PA guidelines. Analyses were mainly descriptive. For categorical variables, data are presented as numbers and percentages. Continuous data are presented as means and SDs; we used means and SDs even for some of the slightly skewed variables in the patient material to match the aggregated data received for controls. For completeness and to enable future comparisons, we present medians and interquartile ranges (IQRs) for key outcome variables for PWH in Suppl. Table 1. Aggregated means and proportions of PA variables were compared between PWH and controls using immediate versions of Welch's two-sample t-test for unequal variance[36] for continuous variables and two-sample test of proportions for categorical variables. A two-sided *P*-value of < .05 was considered statistically significant.

To investigate whether there was a change in PA over the measurement period for PWH, we used boxplots stratified by measurement weeks (1-12) for the outcomes: steps, LPA, MPA, VPA, MVPA, total volume PA, and ran linear regression models for each of those outcomes with measurement week as dependent variable. We used linear mixed model of repeated measures to investigate whether daily total PA changed by calendar month and extracted monthly marginal means with 95% confidence intervals (CIs) from the model.

3 | RESULTS

We enrolled 40 PWH A on continuous prophylaxis and without inhibitors, representing 73% of the eligible participants registered at our HCCC (Figure 1). Mean age was 19.5 (SD 5.7) years, and 20 (50%) were teenagers (aged 13–17 years). Three (7.5%) participants had moderate and 37 (92.5%) had severe haemophilia. Mean weekly factor VIII prophylactic dose was 70 (SD 26) IU/kg. Joint scores were low, over the last 12 months mean number of bleeds were close to zero, and participants had no haemophilia-relevant comorbidities (Table 1). The number of controls was ≈60,000 and the group's mean BMI was 24.5 (SD 5.0).

Each participant wore the Fitbit for 12 weeks (84 days). However, a total of seven measurement days were for unknown reasons not registered for three PWH. Hence, a total of 3353 measurement days were included in our dataset. Out of these, 3023 days (90.2%) were defined as valid and included in the analysis. Mean number of valid measurement days per PWH was 75.6 (SD 12.3). Mean number of valid measurement days per week was 6.3 (SD 1.2) for PWH and 5.8 (SD 1.8) for controls (difference .5 days, 95% CI -.6 to 1.1, $P = .079$).

3.1 | PA of PWH versus controls

3.1.1 | Steps, intensities and PA volume

Mean steps per day and minutes per day spent in MPA and VPA (and thus MVPA) were similar between PWH and controls, while time per day spent in LPA (and thus volume PA) was higher in PWH compared to controls (Table 2). Medians and IQRs are presented in Suppl. Table 1 for PWH.

3.2 | Activity types and exercise sessions

A total of 2712 exercise sessions were registered for the PWH over the study period, whereof the majority (95%) were Fitbit auto detected. The other 5% were manually entered by participants. The most common activity types were walking and 'sport' for both PWH and controls. Because we received proportions that performed selected activities at least once per week for controls, this was also calculated for PWH. Percentages of walking and sport were higher for PWH, while results were similar for the other activity types (Figure 2).

Mean weekly numbers of exercise sessions were 5.6 (SD 3.7) for PWH and 3.3 (SD 1.9) for controls (difference 2.3, 95% CI 1.7-2.9, $P < .001$). For both teenagers and adults, the proportions that exercised at least once, twice or three times per week were higher for PWH than controls (Table 3).

TABLE 1 Characteristics of PWH in the study (N = 40)

	Mean (SD) or n (%)
Age at enrolment (years)	19.5 (5.7)
Age group	
Teenagers (13-17 years)	20 (50%)
Adults (18-30 years)	20 (50%)
Body mass index	23.5 (4.3)
Waist circumference (cm)	80.5 (11.6)
Haemophilia severity	
Moderate	3 (7.5%)
Severe	37 (92.5%)
Age at first joint bleed[a] (years)	1.8 (1.1)
Age at start prophylaxis (years)	3.9 (3.8)
History of inhibitor	
Yes	3 (7.5%)
No	37 (92.5%)
Factor VIII prophylactic dose (IU/kg/week)	70 (26)
Teenagers	73.8 (29.9)
Adults	66.6 (23.4)
Number of joint bleeds last 12 months (AJBR)	.5 (.8)
Number of serious non-joint bleeds last 12 months	.0 (.2)
Hospitalisation due to haemophilia last 12 months	0
History of joint surgery	
Arthrodesis	0
Arthroplasty	0
Synovectomy[b]	2
HJHS 2.1 total	6.3 (7.9)
HEAD-US total cumulative score	2.6 (5.4)
Hepatitis C positive	0
Human immunodeficiency virus (HIV) positive	0
Non-haemophilic joint disease	0
Other relevant medical conditions	0

Abbreviations: AJBR, Annual Joint Bleeding rate; HEAD-US, Hemophilia Early Arthropathy Detection with Ultrasound; HJHS, Haemophilia joint Health Score; IU, International Units; SD, Standard Deviation.
HJHS 2.1 contains scores of 0–20 per joint plus four for gait, with a maximum potential total score of 124. HEAD-US contains a score of 0–8 points for each joint, thus with a potential maximum cumulative score of 48. Lower scores equal better joint status for both tests; The number of patients (n) is noted if it deviates from the total number: [a]n = 28/40, i.e., data missing for 12 participants. [b]Both were ankle synovectomies.

3.3 | Weekly MVPA recommendations

Over the complete 12-week measurement period, overall minutes MVPA/week were mean 399 (SD 174) for PWH and 375 for controls. The separate means for teenagers were 414 min (SD 166) for PWH and 342 for controls, and for adults 386 min (SD 187) for PWH and 384 for controls. Among teenagers, 40% (n = 8) of PWH and 8% of controls met the recommended weekly minimum of 420 min of MVPA. Among adults, 95% (n = 19) of PWH and 100% of controls met the minimum recommendation of 150 min of MVPA per week (Figure 3).

Out of the 12 measurement weeks, PA recommendations were met for mean 5.1 (SD 4.0) weeks (42.9%), min-max: 0 to 12 among the 20 teenaged PWH, and for mean 10.5 (SD 1.7) weeks (87.1%), min-max: 6 to 12 among the 20 adult PWH.

3.4 | PA levels of PWH over the study period

When looking at boxplots of the daily PA variables stratified by measurement week, we found stable PA levels over the 12 weeks for PWH (Suppl. Figure 1). In accordance, there was no association between measurement week and all the PA variables from the linear regression models (all *P*-values > .414). When looking at monthly variation in total minutes of PA per day over the study period for PWH, we found lower levels in the period March-May 2020 (Figure 4).

4 | DISCUSSION

In this study, which is the first to assess PA levels of PWH in Norway, we measured PA over 12 weeks using the activity tracker Fitbit Charge 3 and compared PA levels between 40 young PWH A and general population controls. PWH showed favourable results as compared to controls for several PA aspects: they spent more time in LPA, exercised more frequently, and a larger proportion of teenagers met weekly MVPA recommendations. Results were similar between PWH and controls for number of steps and minutes spent in MPA and VPA.

For children and adolescents, the WHO recommends minimum 60 min MVPA/day, equivalent to 420 min/week.[4] We found that only 40% of teenaged PWH and 8% of the controls met these recommendations. In the general population, 19% of adolescents globally meet these recommendations.[37] Buxbaum et al.[18] found that adolescent PWH spent some more time in MPA than controls, but that most awake time was spent sedentary. Similarly, Gonzales et al.[19] found higher daily mean LPA and MPA among adolescent PWH as compared to healthy controls. However, also there overall MVPA levels were low, with a mean of only 61 min/week. More favorably though, and similar to our results, Bouskil et al.[20] found that children with haemophilia were close to reaching the recommended 60 min of MVPA/day.

For adults, the WHO recommends minimum 150–300 min MVPA/week.[4] Encouragingly, 95% of adult PWH in our study met the lower minimum recommendation of this range. By comparison, 100% of adult controls met the recommendations, whilst the proportion is 73% in the general population globally.[38] In adult PWH, Carrasco et al. found that 85% met recommendations, which is lower than our finding even though those participants were encouraged to increase their PA levels, which was not the case in our study. This difference might be related to a higher mean age (36 vs. 20 years) and lower treatment intensity (28 vs 70 IU/kg/week) in their cohort than ours. Among adult PWH (aged 30–54), Timmer et al. report that the

TABLE 2 Overall mean number of steps and time spent in different levels of PA for PWH compared to controls

	PWH	Controls		
Variable	**Mean (SD)**	**Mean (SD)**	**Difference (95%CI)**	***P***
Steps (number/day)	9783 (5721)	9295 (4154)	488 (−1342 to 2317)	.593
LPA (min/day)	227 (100)	192 (86)	35 (3 to 67)	.033
MPA (min/day)	31 (34)	27 (24)	4 (−7 to 15)	.461
VPA (min/day)	26 (31)	28 (25)	−2 (−12 to 8)	.685
MVPA (min/day)	57 (59)	55 (35)	2 (−9 to 13)	.718
Total PA (min/day)	284 (130)	247 (93)	37 (8 to 66)	.012

P-values comparing PWH and controls were calculated using the immediate form of Welch's two-sample t-test.
Abbreviations: CI , Confidence Interval; LPA, Light-intensity Physical Activity; MPA, Moderate-intensity Physical Activity; min = minutes; MVPA, Moderate and Vigorous intensity Physical Activity; PA, Physical Activity; SD, Standard Deviation; VPA, Vigorous intensity Physical Activity.The overall aggregated daily means are calculated and averaged over all valid days (i.e. mean of all days with > 1000 steps). MVPA = MPA + VPA. Total PA = LPA + MPA + VPA.

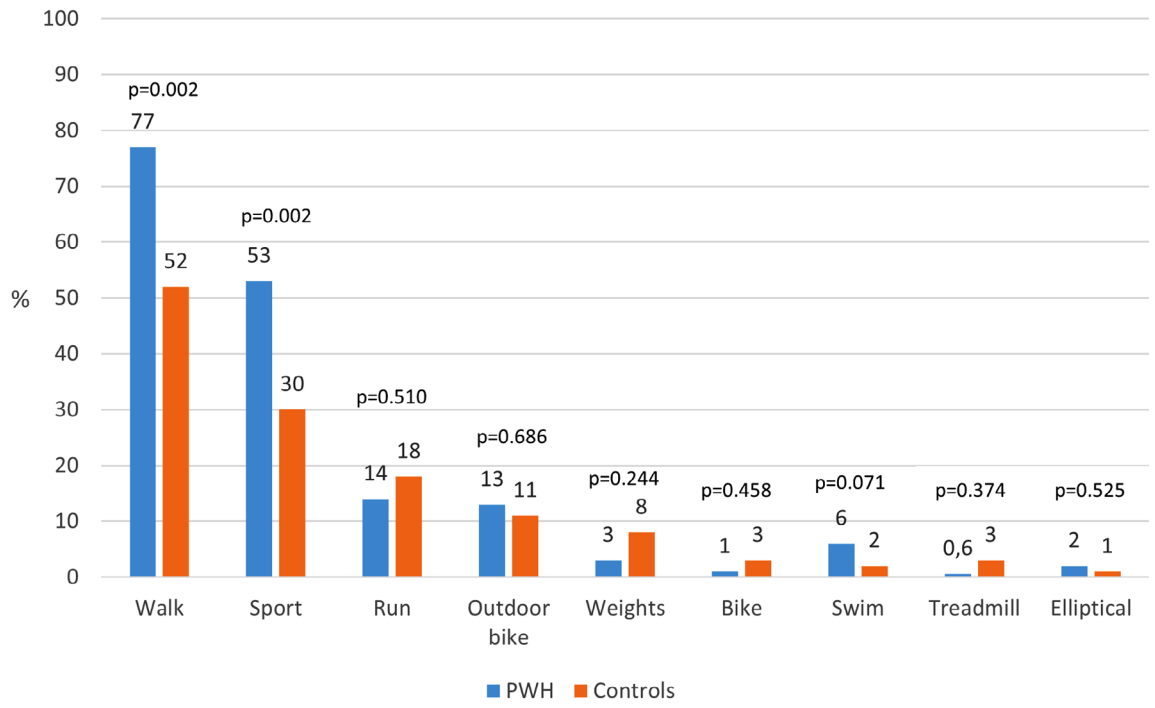

FIGURE 2 Percentages of PWH and controls performing the respective exercise types at least once per week. 'Sport' includes continuous movement sports like for example tennis and basketball. *P*-values comparing PWH and controls were calculated using the immediate form of two-sample test of proportions and are presented over each activity type.

majority were physically inactive,[21] and that they walk and run less and sit and stand more than healthy controls.[39] By contrast, the mean of 386 min MVPA/week in our adult PWH indicates that our group achieved PA levels even beyond the minimum recommendations, which is encouraged in order to achieve further health benefits.

We report more PA in teenagers than adults, but still, since the recommended volume of MVPA/week is higher for teenagers, it is naturally more difficult for that group to achieve the recommendations. Although the PWH in our study appear to be somewhat more physically active than the general population controls, it is worrisome that a significant proportion of teenagers do not fulfil the WHO PA recommendations. This is not only due to health-related aspects, but also because PA early in life is important to lay the foundation for continued PA in adulthood.[40] Thus, we recommend haemophilia treaters to have extra focus on PA promotion for children and adolescents. This should include provision of individualised advice and support for PA, based on an up-to-date understanding of barriers and motivators for PA, including the unique challenges the person with haemophilia may face.[41] More information on the topic can be found elsewhere.[41]

Interestingly, we found that MVPA was similar between groups although proportions of PWH participating in 'sport' at least once per week and undertaking at least one to three exercise sessions per week were significantly higher than in the control group. Our data cannot explain these findings, but we offer a couple of potential

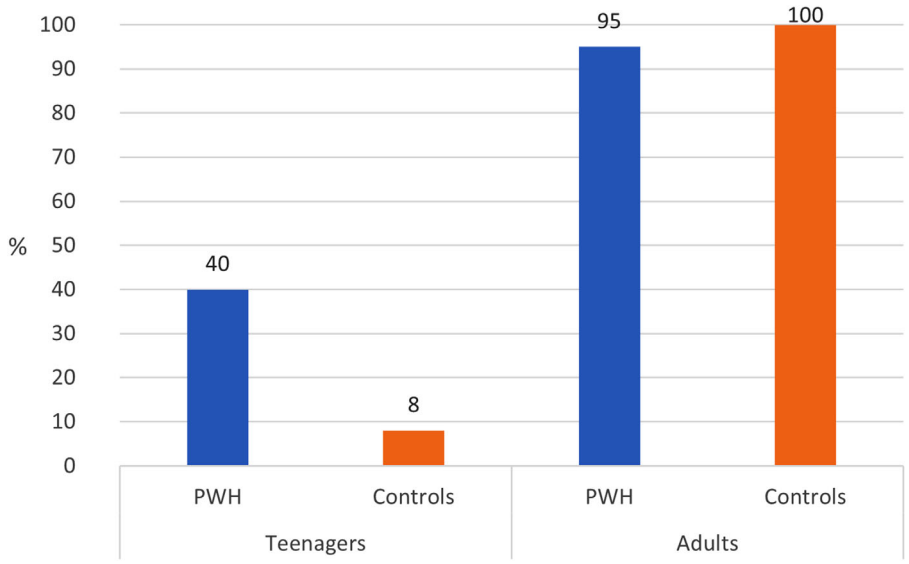

FIGURE 3 Percentages of PWH and controls meeting weekly minimum recommendations for MVPA. PWH, People with haemophilia; MVPA , moderate-to-vigorous physical activity. Minimum weekly MVPA recommendation for teenagers = 420 min and for adults = 150 min.

TABLE 3 Proportion of PWH and controls that exercised at least once, twice or three times per week

	PWH	Controls	*P*
Exercised ≥1x/week, total	91%	70%	.004
Teenagers	97%	68%	<.001
Adults	85%	70%	.039
Exercised ≥2x/week, total	80%	55%	.002
Teenagers	86%	55%	<.001
Adults	74%	55%	=.016
Exercised ≥3x/week, total	70%	42%	<.001
Teenagers	78%	44%	<.001
Adults	61%	42%	.015

Note: ≥1x, ≥2x and ≥3x/weeks means at least once, twice or three times per week, respectively. *P*-values comparing PWH and controls were calculated using the immediate form of two-sample test of proportions.

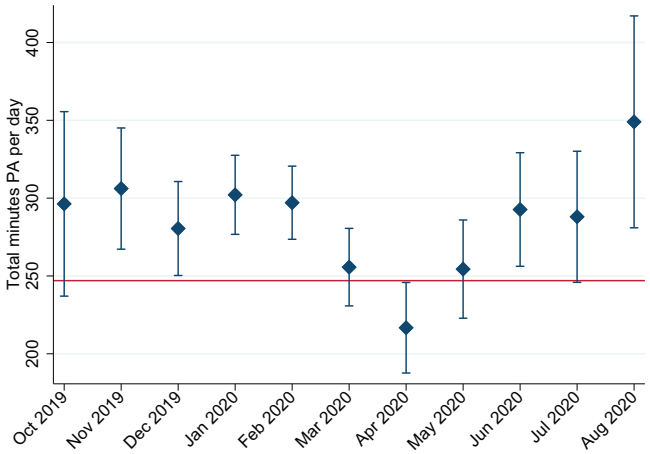

FIGURE 4 Marginal total minutes of PA per day with 95% CI by month for PWH from mixed effects model for repeated measures. The red line represents the overall mean of total minutes of PA per day for the control group. Total PA , total volume of physical activity, i.e. LPA + MPA + VPA. For participants, means are corrected for repeated measurements

reasons: Firstly, it is possible that some lower intensity activities like yoga and Pilates have been classified as 'sport' and that more PWH than controls perform such activities. Secondly, it may be that PWH undertake a higher number of lower intensity exercise sessions with duration of > 15 min than controls, resulting in more registered exercise sessions in the patient group (since sessions < 15 min duration are not automatically registered by the Fitbit).

Our results showed a decrease in PA among PWH in March-May 2020, which is natural, since this coincides with the first COVID-19 lockdown in Norway, when strict social and activity restrictions were imposed, including closing of gyms and schools. Decreased PA of PWH during this period has also been reported from surveys in the Netherlands and France.[42,43]

4.1 | Strengths and limitations

A particular strength of this study is the large control group, providing PA estimates for a large selection of the general population to compare the PA of PWH against. Furthermore, since our PWH cohort represents 73% of the eligible population, our sample is likely representative of PWH A on prophylaxis and without inhibitors aged 13–30 years in Norway. We consider the chance of non-response bias as low since reasons for ineligibility was out of individual's control and random (e.g. not being allowed to wear a watch at work, or that enrolment was concluded) for the majority (11/15) of those not included. Nonetheless,

our results are not necessarily generalisable beyond this population. Older cohorts and those with limited access to treatment are for example expected to have lower PA levels. Another strength of the study is that we took measures to minimise reactivity among PWH to being provided with an activity tracker, including limiting the information available on the home screen of the devices and turning off reminders to move. Additionally, we chose a measurement duration of 12 weeks to get a representative picture of participants' habitual PA. We report stable PA levels of each PWH over the measurement period, indicating no pronounced reactivity. We also report high wear compliance, with > 90% of measurement days defined as valid. Based on this, we believe we have captured the PWH's habitual PA levels.

The current study also has some limitations. We acknowledge that Fitbit overestimation of PA estimates[16] may be a source of bias when comparing our results to studies using different devices. In addition, we do not know whether wear time was the same in the two groups. Furthermore, we do not know whether the control group (male Fitbit users aged 13–30 years) are representative of the general population, nor if controls entered their correct age when they set up their Fitbit accounts. In addition, we do not know which device settings the controls had, and potential differences in settings compared to the patient group may be a source of bias. Due to our observational study design, we cannot establish reasons for the favourable PA results in our participants as compared to controls and other studies. We speculate that this may be related to good health status including limited joint damage in our cohort as well as our centre's provision of early-life start of tailored high-intensity prophylaxis and focus on PA promotion. However, it is possible that PWH kept a higher level of PA than usual over the measurement period because they knew they were being monitored, despite the mentioned stable PA levels over the 12 measurement weeks. Since we did not perform a power calculation for this study, and considering the limited sample size of PWH, the lack of statistically significant differences in steps, MPA, VPA and MVPA between groups may be due to type II statistical error. Furthermore, we have uncertainty in our estimates due to the small sample size and the true PA levels of the PWH could lie somewhere between more active and less active compared to general population peers. Lastly, we were somewhat limited in our statistical analysis options due to the format of the control group data. For example, we had to use mean and SD (as opposed to median and IQR) to compare data of PWH to controls even though some of the variables were skewed with a heavy tail towards higher levels of PA, which may have influenced the mean toward higher levels of PA. Furthermore, the consequent necessary use of parametric, instead of non-parametric methods, is another potential source of bias. In future studies it would be important to obtain detailed control data on the individual level to avoid such challenges.

4.2 | Clinical implications

The current findings imply that young PWH A with access to safe and efficacious continuous high-intensity prophylaxis from early in life have similar opportunities for being physically active as their peers, which is likely linked to limited arthropathy and good health-status. In sum, this indicate that this patient subgroup can participate in society (e.g. work, sports, social life) at a level comparable to the general population, and probably at a higher level than the group of today's older PWH, where the majority is living with the consequences of previously limited treatment (e.g. multi-joint arthropathy).

5 | CONCLUSION

The current findings demonstrate that young PWH A on prophylactic treatment are as physically active as their general population counterparts. This indicates that PWH with access to continuous high-intensity prophylaxis from early in life have similar opportunities for PA as others. Still, we found that a considerable proportion of teenagers do not meet the recommended weekly volume of MVPA and we suggest clinicians to have a particular focus on promoting PA for this group.

AUTHOR CONTRIBUTIONS

REDM, PAH, HG, CSR and MG designed the study. REDM collected the clinical data. REDM and CSR analysed the data. REDM drafted the manuscript. All authors contributed to data interpretation and manuscript revision. All authors approved the final version.

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CONFLICT OF INTEREST

PAH and REDM have received funding to institution from Bayer HealthCare for research carried out in this work. HG, CSR and MG stated that they had no interests, which may be perceived as posing a conflict or bias.

DATA AVAILABILITY STATEMENT

The data supporting the study findings are not publicly available due to privacy or ethical restrictions. Data may be made available upon reasonable request to the corresponding author.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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