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Exploring the use of digital technology for injury prevention and self-management among recreational runners

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ABSTRACT

Objectives: Explore digital technology use among recreational runners in Wales and assess attitudes toward a proposed digital intervention for running-related injury (RRI) prevention and self-management.
Design: Exploratory survey.
Setting: Online questionnaire, closed questions distributed to runners over a 7 week period.
Participants: Recreational runners living in Wales (N = 232).
Main outcome measures: Data analysed descriptively. Inferential analysis conducted via IBM SPSS v25. Pearson's Chi square and logistic regression applied to assess effects of age, sex, and weekly mileage on technology use.
Results: 97% of participants reported using digital technology to monitor training, primarily through running watches (45.1%) and smartphone apps (37.6%). Pearson's chi square indicated that younger (18–24 years) and less experienced runners (3 months–2 years) were more likely to use multiple apps. Runners felt these technologies did not offer realistic advice for RRI prevention or self-management. Most runners (84.5%) were interested in the proposed intervention. Runners wanted to see injury advice, exercises to improve running and a diagnostic feature within the proposed intervention.
Conclusion: Digital technologies are widely used by recreational runners but are not perceived as useful for injury prevention/self-management. There is therefore an opportunity to develop tailored, evidence-based digital interventions for RRI prevention and self-management.

1. Introduction

Recreational running continues to be one of the most popular forms of physical activity (PA) with its physical (Pedisic et al., 2020) and emotional benefits being well documented (Morris & Scott, 2019). Unfortunately running-related injuries (RRI) continue to be a problem for recreational runners and can become a barrier to participation (Peterson, Hawke, & Spink, 2022), with some runners reportedly leaving the sport altogether due to RRI (Fokkema et al., 2019a). Research has reported that incidence of RRI can be anywhere from 19.4% to 79.3% (Van Gent et al., 2007), however more recent research has reported the incidence of RRI to be between 37% and 40.2% (Dempster et al., 2021; Kakouris et al., 2021). Injury locations with the highest prevalence include the knee, lower leg, foot and hip and groin (Hollander et al., 2021; Kakouris et al., 2021; Messier et al., 2018; Taunton et al., 2002).

Alongside the increase in running participation there has also been a rise in runners' use of running-related technology (RRT), such as smartphone applications and GPS watches, to support their running. It has been reported that 90% of recreational runners use RRT (DeJong et al., 2021) and it is common for runners to use more than one RRT (Clermont, Duffett-Leger, Hettinga, & Ferber, 2020; Janssen et al., 2017; Zeng, Cuskelly, & Luo, 2020). RRT allows runners to monitor variables such as running distance, pace, intensity, heart rate and cadence (Nielsen et al., 2019). RRTs are appealing to runners as they can track progress and connect with other runners for support and encouragement. However to aid runners in preventing and managing RRI, more information is needed to identify which RRTs runners use to support running practices, how they use RRTs to support running and whether they would be interested in a digital intervention that would aid prevention and self-management of RRI.

Previous studies have investigated the effectiveness of online interventions in reducing RRI (Adriaensens et al., 2014; Fokkema et al., 2019a; Hespanhol et al., 2018). Adriaensens et al. (2014) found that a web based intervention had a beneficial effect on determinants of RRI behaviour such as knowledge, attitude and intention, but did not result

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in a reduction in RRIs. This was a similar finding to that of Fokkema et al. (2019c) who also found that an online web based intervention for recreational runners was not effective in reducing RRI. In contrast Hespanhol et al., (2018) investigated the effectiveness of a tailored online intervention in reducing RRI among trail runners and found that the intervention was effective for prevention of RRI but did not have a significant effect on preventive RRI behaviours. These studies demonstrate mixed results for online interventions. However, in all studies there was limited involvement of recreational runners or other stakeholders in the development of the intervention. The interventions were also varied in the exposure that runners had to the intervention and the advice given in relation to RRI. One study also noted a low engagement rate with the intervention (Fokkema et al., 2019c). It has previously been noted that perceived usefulness and user satisfaction are under-researched in the field of wearable technologies (Wiesner et al., 2018). The main aim of this study was to map the use of RRT by recreational runners in Wales and their views on a proposed RRI prevention and self-management intervention. The study was conducted in Wales, a region that sees the challenges of chronic disease as well as challenges faced by low- and middle-income populations including challenges of lack of resources and access to healthcare and self-management resources (Welsh Government, 2023).

2. Materials and methods

2.1. Study design

This study employed a quantitative, cross-sectional, online survey design to assess the use of RRTs among recreational runners residing in Wales and gather their perspectives on its potential utility for supporting RRI prevention and self-management. This survey was part of a larger mixed methods study.

The survey was developed using the Jisc online survey platform (static.onlinesurveys.ac.uk) and consisted of close ended questions (Supplementary file) divided into six parts: (i) demographics; (ii) running habits; (iii) training history and level; (iv) RRI history (v) RRI management and prevention (vi) RRT use and what ideal RRI prevention and self-management intervention looks like. Peer review during development aimed to minimize bias and ensure readability. An initial version was piloted and further refined based on feedback e.g enabling participants to bypass questions not relevant to them, allowing multiple choice in questions related to use of RRT and management of RRI. Data was collected for 7 weeks between February and April 2020. RRI was defined as 'a running-related (training or competition) musculoskeletal pain that causes a restriction or stoppage of running (distance, speed, duration or training) for at least seven days or three consecutive scheduled training sessions, or that requires seeking medical attention (Yamato et al., 2015).

2.2. Participants

Between January and February 2020, Run Wales facilitated recruitment of recreational runners by contacting Run Leaders across Wales to distribute the survey link among their running groups. Run Wales is the social running arm of Welsh Athletics, supporting more than 50 social running groups, facilitating participation across all ages and abilities (RunWales, 2017). Additionally, runners were recruited through a link posted in a private Facebook group managed by Run Wales. The survey included recreational runners (232) residing in Wales and aged 18 or older, male and female. For this study runners were defined as anyone running 1–3 times weekly, regardless of how long they had been running. This ensured inclusion of novice runners.

Exclusions applied to elite runners, those on national governing body pathways, and individuals under 18 years old. Prior to survey completion, participants were provided with a participant information sheet outlining the study. Online consent was obtained. Ethical approval was obtained from School of Healthcare Ethics Committee, Cardiff University (SREC reference: REC701). This study was funded by KESS2, a Welsh Government operation which aims to support research and collaboration in areas of Wales facing socioeconomic challenges.

2.3. Data analysis

Statistical analysis was conducted using SPSS Version 27 (IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp). Descriptive statistics, including mean, standard deviation, median, interquartile range, frequency, and percentage, were calculated for demographic data (age, height, weight), running training characteristics, RRI history and management approach and RRT usage. Data were stratified by age, sex, running experience, and average weekly mileage to explore relationships with RRT use for monitoring training, experiences with RRTs and interest in using RRTs for RRI prevention and self-management. Pearson chi square analysis was performed to test those associations with significance level set at $p > 0.05$. A logistic regression model was used to assess an independent effect of age, sex, running experience, and weekly mileage on prior RRTs usage, and interest in using RRTs for RRI prevention and self-management. All p-values were two-sided, with statistical significance set at $p < 0.05$.

3. Results

3.1. Participant demographics

A total of 234 participants completed the online survey. Two participants were excluded as they were under 18 and did not meet the inclusion criteria. This left 232 participants in the final data set (mean = 45.7 SD = 9.7; female = 147) which were included for further analyses. Participant demographics are detailed in Table 1, providing an overview of age, sex, and other relevant characteristics.

3.2. Running training characteristics

Runners were asked about their running and training experience. Table 2 provides more details on participants' running characteristics.

3.3. RRI and approach to RRI management adopted by runners

203 (87%) respondents indicated that they had experienced an RRI. Most runners who responded had been injured between 1 and 3 times (67%). The types of injuries experienced by runners and the most commonly reported injuries are detailed in Fig. 1. Table 3 gives an overview of the RRI management approaches adopted by participants who completed the survey.

3.4. Runner's use of running-related technology

Most participants (97%) reported that they monitored their training. Table 4 provides an overview of how runners monitored training, where runners sourced training programmes and the functions sought in their chosen RRT. Over 50% of participants did not take on board advice on

Table 1
Demographic data of the sample of runners.

	All (n = 232)	Female (n = 147)	Male (n = 85)
Age (years)	44.7 (9.732)	44.6 (8.76)	47.6 (11.26)
Height (cm)	168.1 (9.284)	164 (6.9)	178.1 (12.24)
Weight (kg)	72.51 (15.385)	66.2 (13.8)	80.262 (12.11)
BMI	25 (4.64)	24.7 (4.95)	25.30 (4.05)

Values are mean (SD).

Table 2
Running training characteristics of runners who completed the survey.

Characteristics of runners who completed the study.		Number of participants (%)
Age category	18–24	3 (1.3)
	25–34	25 (10.8)
	35–44	78 (33.6)
	45–54	77 (33.2)
	55–64	36 (15.5)
	65 and above	6 (2.6)
	Did not answer	7 (3)
Weekly mileage	0–5	18 (7.7)
	6–10	72 (30.9)
	10–30	115 (49.4)
	30+	28 (12)
Running experience	Less than 3 months	2 (0.9)
	3 months–2 years	47 (20.2)
	More than 2 years	184 (79)

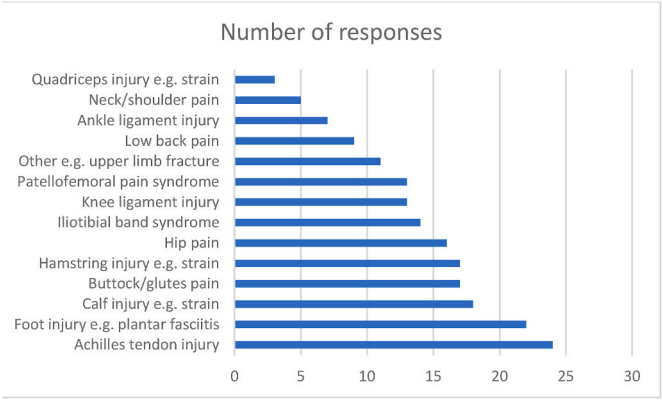

Fig. 1. The most common types of RRI reported by participants who responded to the question 'what was your most recent RRI?'

training volumes, intensity and rest periods, reporting that the advice was not realistic, advised rest periods were too long, they were receiving advice from coaches, or that they tended to listen to their own body.

3.5. Runners views on a proposed digital RRI prevention and self-management intervention

Most participants (84.5%) were in favour of a proposed digital intervention to help them prevent and self-manage RRI. Runners were asked for their views on what content should be included within the proposed intervention and were invited to select multiple responses on the preferred features Participants' responses as to what they felt were desirable features in the proposed intervention are detailed in Table 5.

Further analysis aimed to establish whether there were relationships between sub-groups of runners and behaviours in relation to runners' monitoring of training and the types of RRT they used and found useful. A statistically significant negative association was found between running experience and monitoring training ($\chi 2 = 8.042$, $p = 0.018$, $df = 2$), indicating that being a more experienced runner meant a runner was less likely to monitor training.

The data was analysed to identify if there were relationships between use of smartphone apps, the number of smartphone applications used, and sub-groups of runner. Data was additionally analysed to establish whether there were associations between the types of online resources used by runners to source injury information and sub-groups of runners. Table 6 details these associations. Runners were more likely to use smartphone applications to monitor training if they were male, ran 10–30 miles a week and were aged 45–54 years of age. Runners with 3 months to 2 years running experience were also more likely to use smartphone applications to monitor training.

Table 3
RRI management approaches adopted by runners.

RRI management approaches adopted by runners		Number (%)
How did you manage your last running injury?*	Rest	140 (28.5)
	Self-management (examples included: modified running training, stretching, ice or heat treatment, strength exercises)	126 (25.7)
	Visited a sports physiotherapist/sports therapist	102 (20.8)
	Had a sports massage	64 (13)
	Followed advice from running peers	32 (6.5)
	GP visit	27 (5.5)
What do you find most beneficial when managing an injury?*	Advice from healthcare professionals (e.g. Physiotherapists, GP, Pharmacist)	113 (55.9)
	Massage	70 (34.7)
	Finding the right shoes	59 (29.2)
	Advice from running coach/running leader/running club	41 (20.3)
	Exercise programmes	38 (18.8)
	Online advice	38 (18.8)
	Advice from running peers	31 (15.3)
	Orthotics	17 (8.4)
	Gait assessment	17 (8.4)
	Other	19 (9.4)
How did you self manage your last injury?	Stretching	124 (75.2
	Strength exercises	86 (52.1)
	Ice treatment	73 (44.2)
	Foam rolling	69 (41.8)
	Cross trained i.e. cycling, swimming etc	65 (39.4)
	Modified running training	46 (27.9)
	Heat treatment	40 (24.2)
	Other	11 (6.7)
How much time did you need to take off running due to injury?	1–2 weeks	61 (30.2)
	None I continued to run through the injury	46 (22.8)
	6 + weeks	38 (18.8)
	2–4 weeks	31 (15.3)
	4–6 weeks	26 (12.9)

Key * = participant able to select more than one answer.

Most participants only used one app to monitor training. Further analysis found a statistically significant association between number of apps used to monitor training and the sub-groups of running experience and age category. Runners with 3 months to 2 years of running experience used more smartphone apps to monitor training than those running more than 2 years and novice runners. Runners in the two older age groups (55–64 and 65 and over) were more likely to be using no apps to monitor training.

Runners aged 35–44 (79.2%) and runners who reported average mileage of 6–10 miles per week (52.8%) reported finding physiotherapy/sports therapy websites useful for RRI information. Female runners (100%) and those aged 35–44 were more likely to find NHS sites useful, as did those who ran 6–10 miles per week (71.7%). Male runners (33.3%), who ran 6–10 miles per week (73.1%) and were in the 35–44 age group (78.8%) were more likely to find online videos useful.

Only running experience produced a statistically significant association for being interested in the proposed intervention ($\chi 2 = 7.559$ and $p = 0.023$). Runners with less than 3 months running experience (100%) and those with 3 months to 2 years running experience (95.7%) were more likely to respond that they were interested in the proposed intervention. No relationships were found between the subgroups and the features runners wanted to see from the intervention.

Logistic regression models did not find any predictors for the sub-groups of runners (running experience, average miles per week, age category, sex) and variables related to technology use (monitoring training, smartphone use, number of smartphone apps used, online resources that runners found useful).

Table 4
Runners use of running-related technology.

Runner's use of running-related technology		Number (%)
How do you monitor running training?*	Running watch	188 (45.1)
	Smartphone application	157 (37.6)
	Web platform	42 (10.1)
	Paper diary	26 (6.2)
	Other e.g., spreadsheet	4 (1)
What type of running-related smartphone app do you use?*	Strava	180 (65)
	Other e.g., Garmin connect, Fitbit	60 (21.7)
	Map My Run	15 (5.4)
	NHS Couch to 5K	10 (3.6)
	Nike Run Club	7 (2.5)
	Run Keeper	5 (1.8)
Which brand of running watch do you use?*	Garmin™	164 (75.2)
	FitBit™	18 (8.3)
	Apple™	15 (6.9)
	Other e.g., Samsung™, TomTom™	15 (6.9)
	Suunto™	6 (2.8)
Where do you source your training programmes from?*	I don't follow a programme, I run by how I feel.	90 (22.7)
	Running coach/club/leader	86 (21.7)
	I devise the programme myself	83 (21)
	Online	81 (20.5)
	Running magazines	31 (7.8)
	A book	17 (4.3)
	Other	8 (2)
What do you look for in a smartphone app or GPS watch?	Function to monitor training distances	197 (25.8)
	Function to monitor intensity	172 (22.5)
	Heart rate monitor	132 (17.3)
	Motivation function	78 (10.2)
	Connectivity to other runners	55 (7.2)
	Function to keep track of running shoes	43 (5.6)
	Function to monitor rest	34 (4.5)
What are the key features you look for in a smartphone app or GPS watch?*	Training programme resource	21 (2.8)
	To be able to compete with other runners	19 (2.5)
	Other e.g., music, aesthetics, route planning, cross training	12 (1.6)
Which online resources do you find the most useful?*	Physiotherapy/Sports therapy websites	72 (30.8)
	NHS website	53 (22.6)
	Information video format e.g. You Tube	52 (22.2)
	Online running magazine	52 (22.2)
	Other	5 (2.1)

Key * = participants able to select more than one answer.

Table 5
Features and content that runners want to see in a proposed RRI prevention and self-management intervention. Examples included advice on exercises for better running, injury prevention advice and a self-diagnosis tool.

Features and content that runners want to see in a proposed digital RRI prevention and self management intervention		Number (%)
Which features would you want to see in the Ideal App?*	Resilient runner toolbox to advise on exercises for better running	131 (17.7)
	Injury prevention to advise on the best way to avoid/prevent injury	127 (17.1)
	Self-diagnosing tool to identify an injury	117 (15.9)
	An Injury Free running toolkit to advise on running mileage and training	102 (13.8)
	Recovery guide to guide on injury recovery	99 (13.3)
	Return to running toolbox to advise on when to start running again	99 (13.3)
	Self-screening tool to identify risk of injury	61 (8.3)
	Other	3 (0.4)
Who do you feel should deliver this information?*	Health professionals e.g., Physiotherapists, Sports therapists, doctors, podiatrists	170 (84.6)
	Running coaches/leaders	17 (8.5)
	Fellow runners	8 (4)
	Well-known runners	5 (2.5)
	Other	1 (0.5)
How important is it to you that the information is evidence based?	Very important	164 (80.4)
	Important	36 (17.6)
	Not sure	3 (1.5)
	Not important	1 (0.5)
Would an app advising when to see a health professional be helpful?	Very helpful	126 (54.3)
	Helpful	72 (31)
	Not sure	21 (9.1)
	Not helpful	13 (5.6)
What additional information would you want in the intervention?*	Nutritional information	115 (40.8)
	Hydration information	90 (31.9)
	Information on managing stress.	44 (15.6)
	Sleep advice	26 (9.2)
	Other	7 (2.5)

Key * = participants able to select more than one answer.

4. Discussion

This study addresses the highly prevalent issue of running-related injuries (RRI) among recreational runners, which can significantly impact participation. Growing adoption of RRTs brings opportunities to explore use of technology to help runners prevent and self-manage RRIs. The primary objective of this research was to investigate the current use of RRTs among recreational runners and evaluate attitudes towards a proposed digital intervention aimed at RRI prevention and self-management. This is the first study to systematically examine how recreational runners integrate RRTs into their training practices and assess their preferences to prevent and self-manage RRIs. Our findings demonstrate that a significant number of runners (87%) experienced RRI's, with the majority (92.7%) using a wide range of RRTs to monitor their training and track their progress.

4.1. Digital technology used by runners to monitor training

Most runners in this study monitored their training and did this via smartphone apps and GPS watches, often using more than one method to monitor training. This is a similar finding to previous research (Clermont et al., 2020; Janssen et al., 2017; Zeng et al., 2020) with one study finding that 8 out of 10 runners used at least one monitoring device and 1 out of 4 runners used both a smartphone app and a GPS watch (Janssen et al., 2017). Further analysis identified that runners with 3 months to 2 years' experience were using more smartphone apps to monitor training. Novice runners could be testing apps to try and discover what works for them and in attempts to gain experience to optimize their running (Linton & Valentin, 2020). Previous research identified that apps are more likely to be used by less experienced runners (Janssen et al., 2017). However, even though novice runners have been identified as being more likely to use smartphone apps and using a larger number of apps, experiences of other sub-groups of runners should not be ignored. Competitive runners who ran more than 4 days a week have been reported to be more likely to use running watches to monitor training while recreational runners (running less than 4 days a week are more likely to use smartphone apps (Clermont et al., 2020). This is reflected in the current study which found that runners who ran more than 30 miles a week were more likely to use a smartphone app to monitor training. It is noted that average miles per week and frequency of running are different measures of training load, but both could be argued to relate to volume of running. Therefore, when developing a digital intervention to support RRI prevention and self-management, tailoring to different groups of runners by experience and volume of running per week should be considered so that the information is optimal for runners.

Whilst runner's experience and competitive status may be a possible

Table 6
Results of Pearson chi-square analysis to identify relationships between variables of RRT use and sub-groups of runners.

Variable	Runner sub-group	χ2 value	Level of significance*
Use of smartphone applications to monitor training	Sex	62.504	0.001 (df = 1)
	Age category	139.901	0.001 (df = 5)
	Running experience	8.042	0.018 (df = 2)
	Average miles per week	54.059	0.001 (df = 3)
Number of apps used to monitor training	Sex	3.333	0.504 (df = 1)
	Age category	38.333	0.007 (df = 5)
	Running experience	18.977	0.015 (df = 2)
	Average miles per week	9.894	0.625 (df = 12)
Use of Online Resources			
Physiotherapy/sports therapy sites	Sex	63.633	0.001 (df = 1)
	Age category	111.442	0.001 (df = 5)
	Running experience	1.192	0.275 (df = 2)
	Average miles per week	54.390	0.001 (df = 3)
NHS websites	Sex	41.656	0.001 (df = 1)
	Age category	81.657	0.001 (df = 5)
	Running experience	0.115	0.734 (df = 2)
	Average miles per week	100.656	0.001 (df = 3)
Online information videos	Sex	8.045	0.005 (df = 1)
	Age category	80.667	0.001 (df = 5)
	Running experience	0.001	0.972 (df = 2)
	Average miles per week	96.317	0.001 (df = 3)

p = 0.005*.

reason for the RRTs chosen as alluded to in previous research (Jannssen et al., 2017; Clermont et al., 2020), another important factor is cost. Other than a mobile phone, the use of smartphone apps does not require any additional equipment and are seen as being affordable and accessible (Dallinga et al., 2018; Janssen et al., 2020). Our study participants were from all areas of Wales including areas that are classed as having low socioeconomic status. It is therefore essential to consider cost when developing digitally enabled interventions to support RRI prevention and self-management.

Runners over 65 were statistically significantly less likely to use any smartphone apps to monitor training when compared with younger runners. Runners aged 45–54 were more likely to use a smartphone app to monitor training. The findings of the current study have some comparisons with Wiesner et al. (2018) who reported that runners aged 50–59 and 60–69 were less likely to monitor their training with the main reason being that they preferred to 'listen to their own body'. However the same study found that use of use of wearable devices was associated with being 30–39 years of age which is in contrast with the current study. The study by Wiesner et al. (2018) included walkers and Nordic walkers so the findings cannot be related solely to runners, however overall the findings demonstrate a need for the development and marketing of any future interventions to give consideration as to who the intervention is targeted at and the need for tailoring to enhance the implementation of the intervention.

4.2. Online resources used by runners to source RRI information

Physiotherapy/sports websites, NHS websites and online information videos were reported to be the most useful for RRI information, however there were differences in what sub-groups of runners reported to be useful. Participants aged 35–44 were more likely to report NHS websites, information videos and physiotherapy web sites as useful. Participants running 6–10 miles per week were more likely to report NHS sites and physiotherapy sites as useful. These runners could be argued to be less experienced runners or potentially runners who are currently experiencing RRI due to their low weekly mileage. Runners who were running longer distances per week (10–30 miles a week, over 30 miles a week) were significantly less likely to report online sources of information as useful. This was a similar finding for runners in older categories. This could be argued to be an issue related to trustworthiness of online sources. A previous survey of running coaches and Run Leaders found that participants felt that runners should not rely on internet resources for injury prevention advice and that HCPs were the most reliable sources of this information (Linton & Valentin, 2020). With regards to age, it may be assumed by HCP's that older adults are less likely to engage with digital technologies. However this is a form of ageism (Mace et al., 2022) and has the potential to further compound the issue of older adults experiencing digital exclusion. In contrast it has been reported that older adults are reported to experience anxiety and fear around using digital devices (Steelman, Tislar, Ureel, & Wallace, 2016) so the possibility of digital exclusion should be considered.

Research has found that runners can be both open to the use of RRT but also concerned about privacy and whom training data is shared (Wiesner et al., 2018). Digital interventions should aim to ensure that information is perceived as trustworthy and reliable for all stakeholder groups, as well as ensuring digital inclusion so that the intervention is accessible to all runners.

4.3. A proposed RRI prevention and self-management intervention

The current study found that 84.5% of recreational runners surveyed would be interested in a digital intervention for RRI prevention and self-management, indicating a possible unmet need in this sample of runners. Less experienced runners were identified as more likely to be interested in the proposed intervention. Previous research has highlighted that being a novice runner is a risk factor for the development of RRI (Linton & Valentin, 2020; Videbæk et al., 2015). Future interventions should aim to support less experienced runners who are trying to optimize their running.

Information that runners wanted to see within the intervention included advice on exercises for better running, on the best way to prevent injury and a tool to help find out what type of RRI they have. This is reflected in previous research which has investigated runners' and running coaches' perceptions of contributing factors to RRI, such as overtraining and a lack of knowledge about prehabilitation and strength training (Linton & Valentin, 2020; Saragiotto et al., 2014; Wickström et al., 2019).

Runners have previously cited 'not knowing what to do' as a barrier to engaging in injury prevention (Fokkema et al., 2019b) The current study indicates that runners want RRI prevention and self-management information within any future intervention. By providing evidence based information the barrier of a lack of knowledge can be removed and the intervention becomes a facilitator for runners to engage in RRI prevention behaviours. Qualitative research has identified that preventive strategies given to runners via information, advice and programmes can help runners to manage their complaints and injuries (Verhagen et al., 2021). The proposed intervention has the potential to bring such preventive strategies to recreational runners. Content could be developed that is specific to prevention of the most common injuries identified by runners in the current survey. Engaging with runners to co-produce content is essential to ensure adoption of advice and clarity of the information provided.

It is important to runners that wearable technology used to monitor running has the ability to understand their running patterns, presents data in a meaningful way and can be personalised to fit their needs (Clermont et al., 2020). Future interventions should consider tailoring content towards these findings with regards to sub-groups of runners such as sex, age, running experience and the average distance that

individual runners tend to run per week. Tailoring would enhance the perceived usefulness and appeal to runners (Hu et al., 1999; Mohammadi & Isanejad, 2018) while also empowering runners and enhancing autonomy around decisions they make about their running and RRI (Verhagen et al., 2021). The findings of this survey study provides insights into the perceived usefulness and potential user satisfaction of the proposed intervention and will assist future development.

Data collection occurred in the first half of 2020 when the COVID pandemic and lockdown measures impacted PA habits. The pandemic resulted in forced behaviour changes with many previously inactive people increasing their PA levels (Constandt et al., 2020). Runners ran more frequently during the pandemic, but they also experienced a heightened risk of injury (DeJong et al., 2021; DeJong Lempke & Hertel, 2022). Increases in running behaviour may have led to more people seeking out RRTs to monitor progress, with one study conducted during the pandemic identifying that 90% of runners used technology to monitor training (DeJong et al., 2021). Therefore some of the findings of the present study could have been impacted by circumstances of the pandemic, particularly runners who were new to the sport.

This study is novel in its findings as it provides insights into how recreational runners currently use RRT through the lens of RRI prevention and self-management behaviours and practices. From this study it is clear that they do not use these technologies with this in mind. What is clear is that runners who completed this survey do use online resources such as physiotherapy and NHS websites, and online information videos. This study also identified that there is an unmet need within the recreational running population for a digital RRI prevention and self-management intervention e.g. exercises to improve and optimize running, injury advice and an RRI diagnostic function. Further qualitative research is required to add context to the current findings, which could then be used to develop a prototype for the proposed intervention which could then be tested.

4.4. Limitations

A larger study with a larger sample of runners would have allowed greater inferences to be made via statistical analysis on whether there are predictors for use of RRTs.

This study was conducted on recreational runners in Wales, a single nation with areas of low socioeconomic status, therefore generalizability of the findings to the larger recreational running population is limited. However individuals from lower socio-economic areas tend to be underrepresented in research which therefore becomes a strength with regards to equality and diversity.

Adopting a survey with closed questions will have limited the depth of data gathered and limited any context within the answers given. Further qualitative research with recreational runners would help to explore the survey findings further to gain greater insights and understanding. Using an online method also limits the survey to those who have access to the internet.

5. Conclusion

This study provides novel insights into how recreational runners incorporate RRTs into their running practices, online resources that they find useful for RRI information and what runners think should be included in future digital interventions for the prevention and self-management of RRI. Runners do not currently perceive RRTs to be useful for RRI prevention and management and therefore seek out information from online resources such as physiotherapy and NHS websites. There was strong interest from runners in a proposed digital RRI prevention and self-management intervention, with runners reporting that desired content would include exercises to optimize running, RRI prevention advice, and a tool to help diagnose their RRI. As runners are not currently using RRT to prevent and manage RRI it is important to consider training practices and decisions when discussing RRI with runners. Runners clearly desire information on RRI prevention and self-management and therefore development of digital interventions that are perceived to be useful by runners should be developed. These findings should be used to inform development of digital interventions for runners. Qualitative research with runners and other stakeholders is required to develop an intervention that is likely benefit the recreational running communities.

CRediT authorship contribution statement

Kathleen Walker: Writing – review & editing, Writing – original draft, Visualization, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Nicola Phillips:** Writing – review & editing, Validation, Supervision. **Liba Sheeran:** Writing – review & editing, Validation, Supervision, Funding acquisition.

Ethical statement

This work was approved by the School of Healthcare Ethics Committee at Cardiff University. (SREC reference: REC701).

All participants in this study gave informed consent to the work.

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Knowledge Economy Skills Scholarships (KESS 2) is a major pan-Wales operation supported by European Social Funds (ESF) through the Welsh Government. KESS 2 links companies and organisations with academic expertise in the Higher Education sector in Wales to undertake collaborative research projects, working towards a PhD or Research Masters qualification. Research elements are integrated with a higher-level skills training programme, leading to a Postgraduate Skills Development Award.

Key Objectives of KESS2.

- To increase the research capacity of small to medium enterprises (SMEs) by linking with a PhD/Research Masters project
- To encourage SMEs to undertake research and recruit researchers
- To prepare and train individuals to contribute to research as professionals
- To support the development of key technologies in the Convergence Area of Wales
- To promote higher-level skills development

Declaration of competing interest

No conflict.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2024.12.004.

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