

1 **SHUTTLE TIME FOR SENIORS: THE IMPACT OF 8-WEEKS STRUCTURED BADMINTON**
2 **TRAINING ON MARKERS OF HEALTHY AGEING AND EVALUATION OF LIVED**
3 **EXPERIENCES: A QUASI-EXPERIMENTAL STUDY**

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10 **RUNNING TITLE: BADMINTON TRAINING INTERVENTION FOR HEALTHY AGEING**

11 **KEY WORDS:** Sport; Older Adults; Physical Activity; Intervention Development

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1 **ABSTRACT**

2 *Background/Objectives:* Engagement in sport offers the potential for improved physical and
3 psychological wellbeing and has been shown to be beneficial for promoting healthy ageing.
4 Opportunities for older adults to (re)engage with sport are limited by a paucity of age-appropriate
5 introductory sports intervention programmes. As such, the study evaluated the efficacy of a newly
6 designed 8-week badminton training programme (Shuttle Time for Seniors; STS) on markers of
7 healthy ageing and the lived experiences of participation. *Methods:* Forty-three older adults assigned
8 to a control (N=20) or intervention group (N=23) completed pre-post assessment of physical and
9 cognitive function, self-efficacy for exercise and wellbeing. Focus groups were conducted for
10 programme evaluation and to understand barriers and enablers to sustained participation. *Results:*
11 Those in the intervention group increased upper body strength, aerobic fitness, coincidence
12 anticipation time, and self-efficacy for exercise. Objectively improved physical and cognitive function
13 were corroborated by perceived benefits indicated in thematic analysis. STS was perceived as
14 appropriate for the population, where the age-appropriate opportunity to participate with likeminded
15 people of similar ability was a primary motivator to engagement. Despite willingness to continue
16 playing, lack of badminton infrastructure was a primary barrier to continued engagement.
17 *Conclusion:* STS offered an important opportunity for older adults to (re)engage with badminton,
18 where the physical and psychosocial benefits of group-based badminton improved facets important
19 to healthy ageing. *Significance/Implications:* Age-appropriate introductory intervention programmes
20 provide opportunity for older adults to (re)engage with sport. However, important barriers to long
21 term engagement need to be addressed from a whole systems perspective.

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23 **KEY WORDS:** Physical Activity, Sport, Older Adults, Intervention Development

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1 INTRODUCTION

2 Maintaining physical function, independence and quality of life (QoL) are important facets of
3 successful ageing (Anton et al., 2015; Urtamo et al., 2019). Given unprecedented growth in the older
4 adult population (WHO, 2018), promoting healthy ageing is a public health and economic priority
5 (Beard & Bloom, 2015; Cruz-Jentoft et al., 2019). Commonly, the negative impacts of increasing age
6 are associated with a decline in skeletal muscle function, where muscle weakness is associated with
7 reduced physical function, chronic disease, poor QoL and all-cause mortality (Cavel-Greant et al.,
8 2012; Li et al., 2018; Moreland et al., 2004; Wolfe, 2006). Skeletal muscle function is an integral
9 component of the bidirectional relationship between physical function and wellbeing (Steinmo et al.,
10 2014), where an age-induced decline in muscle contractility and impaired physical function can
11 contribute to feelings of social isolation (Nicholson, 2009), depression (Chang et al., 2017) and
12 suicidal ideation (Noh & Park, 2020), which in turn cause further impaired physical health (Davies et
13 al., 2021).

14 Many detrimental effects of ageing are ameliorated by physical activity (PA) (Cunningham et
15 al., 2020; Vogel et al., 2009a). Physically active older adults have reduced risk of all-cause mortality,
16 development of non-communicable diseases, falls, activities of daily living (ADL) disability and
17 cognitive decline resulting in improved QoL and a healthier ageing trajectory (Cunningham et al.,
18 2020). Globally older adults are among the least physically active groups (Hallal et al., 2012). The
19 most recent data indicates that 70% of 65-74 year olds in England are active, declining to 31% in
20 those over 85 years (NHS-Digital, 2020). Poor PA engagement in older adult populations has been
21 attributed to physical, behavioural, and economic constraints. More specifically, physical capability,
22 lack of enjoyment, fear of injury, low-self efficacy, financial implications and a lack of age-appropriate
23 opportunities are regularly cited barriers (Gellert et al., 2015; Gray et al., 2016a; Horne et al., 2013).
24 Effective, inclusive and sustainable ways to promote PA and support long-term participation have
25 become an essential part of public health strategy (Public Health England, 2021), where the COM-
26 B model at the heart of the Behaviour Change Wheel (BCW) explains how capability, opportunity
27 and motivation are the key facets of behaviour change (Michie et al., 2011).

1 Age-appropriate group-based exercise, using sport as a vehicle, has received recent
2 attention where combining the physical and social aspect of sport has been shown to be effective
3 for improving physical and psychosocial facets important for the promotion of healthy ageing
4 (Duncan et al., 2022; Gayman et al., 2017). Whilst individuals that continue to play sport across the
5 life course experience health benefits (Oliveira et al., 2023), it is recognised that sport has not been
6 widely explored as a PA opportunity for older adults (Jenkin et al., 2017). There is a scarcity of
7 research dedicated to the development and assessment of the effectiveness of sports interventions
8 suitable for older age groups. Among the limited studies that have attempted to address this issue,
9 most have utilised soccer and match play as the means of investigation (Arnold et al., 2015; Duncan
10 et al., 2022; Reddy et al., 2017). Given that match play requires some degree of tactical and technical
11 skill competency, and that perceived capability and self-efficacy are commonly cited barriers and
12 enablers to PA engagement in older adult populations (Gray et al., 2016b; Lees et al., 2005), match
13 play focused interventions may limit broader engagement. As such, age-appropriate structured and
14 progressive training interventions are needed to help overcome well cited capability and opportunity
15 barriers to PA and to aid in providing the impetus for sustained PA behaviour. Given the limited
16 logistical burden and impact of seasonality, combined with its physiological, biomechanical and
17 cognitive demand (Manan et al., 2018; Ooi et al., 2009; van de Water et al., 2017), a structured and
18 progressive programme of badminton for older adults, that harnesses the superior psychosocial
19 benefits of group based exercise, is well placed to develop physical health, wellbeing and QoL.
20 Recent evidence demonstrates benefits of the Badminton World Federation's (BWF) Shuttle Time
21 programme, a school-based badminton intervention that has been shown to improve fundamental
22 movement skills in children (Chen et al., 2021; Duncan et al., 2020). However, to date there is no
23 evidence to support the efficacy of a badminton specific intervention for older adults.

24 Evidence suggests that psychosocial factors such as enjoyment, social and environmental
25 support rather than biomedical variables have greater influence on sustained participation in exercise
26 (Lautenschlager et al., 2004; Zubala et al., 2017). Older adults are more compliant with PA
27 interventions that promote self-efficacy (Chase, 2013) and where the focus is on competency rather
28 than outcome (King, 2001). Based on these principles we have developed the first badminton-based

1 intervention for older adults (Shuttle Time for Seniors) that is inclusive of ability, fitness, and physical
2 function. Using an adapted version of BWF's Shuttle Time, the programme focused on the
3 development of social health and the physical capabilities and technical abilities to develop
4 badminton specific movement competency, where such benefits will translate into improved
5 functional fitness, self-efficacy for exercise and wellbeing. More specifically, the present study used
6 a mixed methods approach to evaluate the effects of the 8-week Shuttle Time for Seniors (STS)
7 intervention on functional fitness, wellbeing, badminton specific skill and to understand the lived
8 experiences of undertaking in STS. As such, this study will provide evaluation of the effectiveness
9 of a badminton specific intervention for older adults and gain participant's perspectives to refine the
10 programme and to understand barriers and enablers to sustained engagement.

11

12 **METHOD**

13 *Participants*

14 Following ethics approval from the host institute and written informed consent, a quasi-
15 experimental design was used where 50 participants were recruited and assigned by the lead
16 investigator to a control (N = 26) or intervention group (N=24). Groups were matched for age, body
17 composition and baseline functional fitness. The STS intervention was designed specifically for
18 adults aged 60 yrs. and over, with no or limited recent badminton experience, and to be inclusive of
19 fitness capabilities. Participants were screened using the Physical Activity Readiness Questionnaire
20 (PAR-Q), a self-screening tool to determine safety and possible risks to PA engagement based on
21 health history. Participants were excluded if they had been diagnosed with a chronic medical
22 condition that prevented safe completion of the assessments or had a musculoskeletal
23 injury/condition that had either not been fully rehabilitated or would be aggravated by increased PA.
24 Six members of the control group did not complete the follow-up assessment for reasons unstated.
25 One member of the intervention group did not complete post assessments due circumstances not
26 associated with the intervention. As such, the final study sample included 43 participants (N=20 in
27 the control group and N=23 in the intervention group).

1 A sequential mixed method, pragmatistic approach was utilised to address the primary aims
2 of the project where the experimental procedures were split into two distinct parts. In part one,
3 participants completed a battery of healthy ageing assessments 8-weeks apart (Fig 1). Participants
4 in the control group were instructed to continue with their habitual PA behaviours. Participants in the
5 intervention group completed an 8-week badminton intervention, STS, designed specifically for this
6 project to develop functional fitness and badminton specific skill. In part two, the lived experiences
7 of participants that completed the intervention was assessed by conducting and analysing
8 information gathered from focus groups. All assessments took place between January 2022 and
9 May 2022.

10 [Insert Figure 1 Here]

11 **Part 1: Healthy Ageing Assessments & Shuttle Time for Seniors**

12 All participants completed questionnaires to evaluate wellbeing, perceived barriers to
13 exercise and self-efficacy for exercise following assessment of body composition, coincidence
14 anticipation time and functional fitness. Assessment took place at either the host institute's human
15 performance laboratory or at a community sports centre. Assessments were carried out in the order
16 outlined below.

17 *Self-Efficacy for Exercise, Wellbeing & Benefits and Barriers to Exercise*

18 Each participant completed paper-based versions of the Warwick-Edinburgh Mental
19 Wellbeing Scales (Tennant et al., 2007) (WEMWBS) Self-Efficacy for Exercise Scale (SEE) (Resnick
20 & Jenkins, 2000), Exercise Benefits/Barriers Scale (EBBS) (Sechrist et al., 1987).

21 *Body Composition*

22 Participants were asked to remove shoes, socks and heavy clothing before stature (cm) was
23 assessed using a stadiometer (SECA Instruments Ltd., Germany). Body mass (kg), muscle mass
24 (% of total body mass), and fat mass (% of total body mass) were measured using hand to foot multi-
25 frequency bioelectrical impedance (MF-BIA; TANITA MC-780, TANITA, Japan; impedance
26 frequencies 5, 50 and 250kHz). MF-BIA has been shown to have acceptable accuracy compared to

1 dual-energy X-ray absorptiometry (DEXA) for measures of adiposity and lean mass (Faria et al.,
2 2014) and is reliable for assessment of body composition in older adults (Yamada et al., 2017). MF-
3 BIA devices allow for accurate assessment irrespective of time of day and without the need to impose
4 nutritional constraints (Verney et al., 2015). Body mass Index (BMI; kg/m²) was determined as body
5 mass / stature².

6 *Coincidence Anticipation Time*

7 Coincidence anticipation time (CAT) was measured using a Bassin Anticipation Timer (Model
8 35575, Lafayette, USA). CAT refers to the ability to predict the arrival of a moving object at a
9 particular point in space and effectively coordinate a movement response (Payne, 1986). CAT is
10 therefore considered a test of perceptual-motor coupling requiring integration of sensory-cognitive
11 processing and sensory-motor integration (Fleury & Bard, 1985). CAT is fundamental to a multitude
12 of activities of daily living such as making judgement of when to safely cross a busy road, pick up an
13 object, shake hands or walk through a crowd of shoppers.

14 Participants were asked to stand directly behind the Bassin Anticipation Timer, which was
15 set up vertically from the front of them and angled toward them at 45°. The assessment was set-up
16 using three sections of runway (2.24 m) where during completion of each attempt the system's LEDs
17 were sequentially illuminate in a linear pattern moving distally to proximally in front of the participant.
18 Participants were asked to stop the sequential movement of illuminated LEDs as close to the arrival
19 of the stimulus at the target location (runway 3, light 13) as possible using either a button press
20 (control group) or by swinging a badminton racquet underarm through the system movement sensor
21 switch (intervention group). Each test started with random cue delay between 1-2 s to prevent
22 familiarity with the initiation of the test influencing performance. Participants completed 10 practice
23 attempts at each of the assessment speeds before completing 10 recorded trials. 3 mph and 8 mph
24 were evaluated to represent slow and fast stimulus speeds respectively (Tallis et al., 2013). For each
25 of the recorded trials, the time (ms) that the sequence of illuminated LEDs was stopped prior to or
26 following the target was recorded.

1 For each participant, raw scores across each of the stimulus speeds were summarised into
2 three error scores as per previous work (Tallis et al., 2013). Constant error, the temporal interval
3 between the arrival of the visual stimulus and the end of the participant's motor response, was
4 recorded as a representation of the mean response of an individual and the direction of error: early
5 or late. Variable error, the standard deviation of mean response, was recorded as a representation
6 of variability/inconsistency of responses. Absolute error was also determined as the absolute value
7 of each raw score disregarding whether the response was early or late.

8 *Functional Fitness*

9 Given their links to all-cause mortality (Bohannon, 2019), grip strength and gait speed were
10 measured, followed by completion of the Senior Fitness Test (SFT).

11 Isometric hand grip strength for the dominant side was measured following the procedures
12 outlined by the American Association of Hand Therapists as described in previous work (Wearing et
13 al., 2018). Participants were seated in a chair without arm support, with feet resting on the floor and
14 hips flexed to 90°. The assessment was carried out with the elbow of the assessed arm flexed to
15 90°, the forearm neutral and the wrist withing 15-30° of extension (dorsiflexion). Initially the handle
16 of the hand grip dynamometer (Takei 5401, Takei Scientific Instruments, Japan) was adjusted to a
17 position where the participant felt able to squeeze as hard as possible follow submaximal attempts.
18 During measured assessments, participants were asked to squeeze the handle as hard a possible
19 for ~5 s. Participants were permitted three attempts, separated by a minimum of 30 s of rest. The
20 highest value was used for further analysis.

21 Normal 4-meter gait time was measured using timing gates (Brower TCi, Brower Timing
22 Systems, UT, USA). From a standing start, participants were asked to walk at “the speed at which
23 you would walk to the shops”. As per previous work (Forte et al., 2013), in order to account for
24 acceleration, timing gates were placed at the 2nd and 6th m and the mean time of three attempts was
25 recorded.

1 Further assessments of functional fitness followed the procedures outlined in the Senior
2 Fitness Test (SFT) battery (Rikli & Jones, 1999b). The SFT is valid, reliable and allows performance
3 comparison to age-specific normative values and age-appropriate thresholds for maintaining
4 functional independence (Rikli & Jones, 1999a, 2013). Participants completed Arm Curl (upper body
5 strength endurance), Chair Stand (lower body strength endurance), Timed-Up & Go (lower body
6 power, balance and agility), Chair Sit & Reach (lower body flexibility), Back Scratch (upper body
7 flexibility), and the Six-Minute Walk (6MWT; aerobic endurance) assessments as per the procedures
8 outlined in the supplementary material (ST1). In each case, performance was assessed following
9 demonstration and practice attempts.

10 *Short Serve Test*

11 Short serve ability of the participants involved in the intervention was assessed using the
12 procedure outlined by Edwards et al. (2005). On a badminton court with standard measurements,
13 participants were asked to stand in the front corner of the right service box, where the centre line
14 and service line intersect. Using a backhand serve, participants aimed for a 1-meter grid placed at
15 the front of the receiver's service box, where the short service lines and centre court line were used
16 as two edges of the square. Following two practice attempts, performance was assessed across 10
17 trials with a 'miss' recorded if the shuttle did not fall within the grid and a 'hit' recorded if the shuttle
18 fell within the grid.

19 *Shuttle Time for Seniors*

20 Those in the intervention group completed the STS programme. STS was developed using
21 the original BWF Shuttle Time programme (BWF, 2023) as a basis. The original BWF Shuttle Time
22 is a 22-lesson school badminton programme, where fun/competitive game-based scenarios are used
23 to develop physical, technical and tactical competency for badminton. The 8-week STS programme
24 was designed by the research team (MN, JT, EE, RM, DR), all of whom have a sport science
25 background and have either coaching experience at grassroots and professional level and/or have
26 delivered successful exercise interventions with older adults as part of previous research projects.

1 The STS programme focused on a constraints-led approach which was supported by
2 demonstration, opportunity for trial and error and coach feedback. Each session was split into four
3 distinct sections, consisting of a warm-up, game-type activity, constrained match play and a cool
4 down. Game-type activity and constrained match play were designed around specific session
5 themes based on the principles of BWF Shuttle Time programme for children. The 8-week
6 programme focused on developing fundamental badminton skills, movement competency and was
7 progressive in PA demand. Whilst these principles mirror those of the BWF Shuttle Time programme
8 for children, STS was designed to provide an age-appropriate challenge considering individuals that
9 wanted to (re)engage with badminton through to those where the programme provided first exposure
10 to the sport. The original Shuttle Time programme is designed as an introductory programme for
11 delivery by physical education teachers, where each session focuses on the development of specific
12 badminton skill or tactic. Whilst skill and tactical development were an important focus of STS, where
13 basic badminton skills were introduced and reinforced within and between sessions, skill and tactical
14 development was integrated into a weekly multicomponent programme. Specifically, activities were
15 designed to develop important physical capabilities that deteriorate with increasing age (muscular
16 strength and power, aerobic capacity, balance, flexibility, and agility) using movement patterns that
17 mimicked ADL. Effective multicomponent exercise programmes represent an important strategy to
18 facilitate the achievement of physical activity guidelines.

19 Feedback on STS was sought from older adults with limited or no recent badminton
20 experience (N = 2) and a practitioner with no specific experience of badminton but a professional in
21 delivering fitness classes for older adults. In all cases, an electronic version of the draft STS
22 programme was sent to participants recruited and either verbal or written feedback was provided.
23 The purpose and importance of the programme was recognised in the feedback, as was the focus
24 on elements further to match-play. An 8-week intervention with one-hour session was deemed to be
25 appropriate to provide an insight into the sport. With respect to development, feedback was specific
26 to considering further differentiation of activities to encompass a broader range of physical
27 capabilities. Consideration of specific health conditions and/or physical constraints were most
28 frequently suggested, where arthritis in hands, knees and back, poor balance and coordination were

1 mentioned. More broadly, providing opportunity for social engagement and consideration of how to
2 provide an appropriate level of challenge in a mixed ability group were suggested to be important.
3 This feedback was reviewed by members of the research team (MN, JT, EE) the STS was modified.
4 Details of the STS programme delivered can be found as supplementary information (SF1).

5 STS was delivered on a single occasion in a group format where participants attended a
6 single 60-minute morning session (Friday's at 11:00 am) once per week. Sessions took place in a
7 sports hall at the host institute, with markings for four badminton courts. Sessions were led by an
8 individual with a sport and exercise science background who had coaching experience of youth and
9 adult team sport and martial arts, but no experience specifically of coaching badminton or sport for
10 older adults. Sessions were supported by a final year BSc. Sport and Exercise student, with no
11 previous badminton coaching experience, who supported the lead coach to gain experience of
12 working with older adults for PA promotion. The threshold for data to be included in the final analysis
13 was attendance at a minimum of six of the eight planned sessions. Eight of the participants (35%)
14 attended all eight sessions, whilst 11 (48%) and 4 (17%) attended seven and six sessions
15 respectively. On the small number of occasions where participants were unable to attend, medical
16 appointment, illness, or planned vacation was cited.

17 *Statistical Analysis of Data*

18 Following appropriate checks of normality and homogeneity of variance, parametric statistical
19 analysis was performed. Body composition and functional fitness were assessed using two factor
20 mixed model ANOVA. Group (Control vs. Intervention) was used as the between subjects factor and
21 Time (Pre vs Post) used as the within subjects factor. Significant interactions were explored with
22 Bonferroni corrected pairwise comparisons. Partial eta squared (ηp^2) was calculated as an estimate
23 of effect size and interpreted as small (>0.01), medium (>0.06) or large (>0.14) (Richardson, 2011).
24 On a small number of occasions, normality was violated. However, ANOVA is still considered a
25 robust statistical method in such cases (Blanca et al., 2017).

26 Performance in the short serve test was evaluated using a paired t-test and differences in
27 age and height between the intervention and control groups were evaluated using an independent

1 samples t-tests. For t-tests and pairwise comparisons, Cohen's d was calculated and corrected for
2 bias using Hedge's *g* (Lakens, 2013). Hedges *g* effect size was interpreted as trivial (<0.2), small
3 (<0.6), moderate (<1.2) or large (>1.2) (Hopkins et al., 2009). Data are presented as mean \pm S.E.M.
4 Statistical analysis was performed using SPSS 26.0 (Chicago, IL, USA) and graphical presentation
5 of data was performed using GraphPad Prism (Version 10.0, San Diego, California). Statistical
6 significance was *a priori* set at an alpha level of $P < 0.05$.

7 **Part 2: Lived Experiences of Shuttle Time for Seniors**

8 To ensure explicit and comprehensive reporting, the consolidated criteria for reporting
9 qualitative research was used to guide the reporting process (Tong et al., 2007). Information
10 regarding experience of the research team, reflexivity, and relationship with participants is outlined
11 in as supplementary information (SF2) and the COREQ checklist with corresponding page numbers
12 in SF3.

13 *Study Design: Selection, Setting, Data Collection*

14 A phenomenological approach was adopted given the intention to gain understanding of STS
15 from the perspective of those who experienced it. Phenomenology is considered particularly well-
16 suited for investigating intricate challenges in health professions education (Neubauer et al., 2019).
17 A purposive sample, which were all participants who had completed the STS intervention, were
18 recruited via face-to-face discussion upon completion of the final session. Homogenous focus groups
19 were used as the preferred method for understanding the collective views of the participants that
20 completed the intervention based on similar characteristics i.e., their perceived ability. Within each
21 of the STS sessions, differentiation of tasks was achieved by manipulating the challenge on each
22 badminton court with progressing task difficulty. Participants were free to choose the level of
23 challenge that best suited their ability and were free to move between courts within and between
24 tasks. Over the course of the intervention this naturally evolved into the formation of three groups
25 based on perceived capability. Focus groups were selected to enable collective discussions about
26 participants similar experiences whilst encouraging a range of responses. Given that the group had
27 played badminton together and engaged in regular social interaction it was felt that group dynamics

1 would work well putting the interaction into the hands of the participants rather than the researcher
2 to enable in-depth discussions about their experiences and the group process assisting group
3 members to explore and clarify their points of view (Liamputtong, 2011). An upper sample size
4 strategy was used in line with the study goals, in that all involved (n = 23) were invited to take part
5 (7 declined due to commitments that prevented attendance at the time the focus groups were
6 scheduled), representing 78% (18/23, 6/8 females) of participants. Participants were White British,
7 typically of middle to high socioeconomic status, were either retired or semi-retired and had a range
8 of hobbies including gardening, walking and volunteer work. Individuals in the high perceived ability
9 group (focus group 2), more frequently reported engagement in structured sport (e.g. tennis) and
10 exercise classes. All focus groups were conducted at the university site at the same time for which
11 participants were attending the badminton intervention. This was an environment for which they were
12 familiar with and had been attending weekly. McNamara's eight principles of interviewing were
13 followed (McNamara, 2009).

14 In accordance with published recommendations, each focus group consisted no more than
15 seven participants, lasted ~90 min, and used a single semi-structured technique based on six pre-
16 determined, open-ended questions (Gill et al., 2008) outlined in the supplementary information
17 (SF3). No repeat interviews were conducted. Questions were based on building rapport and
18 developing an understanding of three topic areas, interests and expectations of the programme,
19 experience of the programme, and sustainability of behaviour and hopes for the future in line with
20 guidance from constructing effective questions for focus groups (McNamara, 2009). EE developed
21 the interview schedule was piloted with the third and last author to help the researcher identify any
22 flaws or limitations prior to data collection (Kvale, 2008). Feedback from the pilot phase was used to
23 adjust the interview schedule to reduce misunderstanding and to develop prompts to gain further
24 understanding (Creswell, 2007; Hagens et al., 2009). Three focus group discussions were
25 scheduled. Focus group discussions were facilitated by MD and MN with JT and EE observing the
26 discussions and taking field notes.

1 Audio recordings of each focus group were collected using an Olympus DS-2400 digital voice
2 recorder, lasting 48.19 min (FG1; N = 5; 4F), 49.26 min (FG2; N = 6; 1F) and 73.00 min (FG3; N =
3 7; 1F). Field notes were also taken. Audio was transcribed verbatim using Microsoft Word (Microsoft
4 Corporation, Washington, US.) and checked manually by two members of the research team (EE,
5 JT). Transcripts were anonymised using [Number] to represent the focus group, [Number] to
6 represent the participant, [M/F] to represent the participant's sex. These were then manually checked
7 by EE. Transcripts were not returned for comment or correction given the four dilemmas that are
8 discussed in detail in the work of Mero-Jaffe (2011). Instead, paraphrasing was used during the
9 interviews to check that the researcher had understood the views of the group and participants
10 provided the opportunity to reflect upon this. Given the nature of the purposive sampling strategy
11 and the goal of the study to speak to all involved (upper sample size limit), recruitment could not
12 continue until the point of saturation where no new relevant knowledge was obtained.

13 *Qualitative Analysis*

14 Inductive thematic analysis was conducted as suggested by Braun and Clarke (2006). Key
15 themes were identified via a step-by-step analytical process involving data familiarisation through
16 transcription, reading and re-reading the transcripts, code generation where short descriptive labels
17 were assigned to the entire data set, categorisation where similar descriptive labels formed
18 categories, searching for and reviewing the themes, and defining and naming themes. This process
19 was conducted by one author (EE) and resulted in a thematic map with themes, subthemes,
20 associated quotes and relationships. Throughout the focus groups, analytical process and reporting
21 of results, field notes (during), reflexivity, debriefing and critical friend discussions (MD, MN, JT, EE)
22 were held to be transparent about selective and interpretive bias, to debate and re-define themes
23 and develop rigour (Lincoln & Guba, 1985; Smith & McGannon, 2018).

24

25 **RESULTS**

26 **Part 1: Healthy Ageing Assessments & Shuttle Time for Seniors**

1 *Participant Characteristics & Body Composition*

2 Age and height did not differ between intervention and control groups (Table 1. $P > .694$;
3 $g < .392$).

4 [Insert Table 1 Here]

5 For body mass and BMI, there was no significant Group*Time interaction (Table 2. $P < .149$;
6 $\eta^2 < .051$), no main effect of group (Table 2. $P > .309$; $\eta^2 < .026$), but both body mass and BMI were
7 lower when assessed post the intervention period (Table 2. $P < .023$; $\eta^2 > .121$). For percentage
8 muscle mass and fat mass there was no Group*Time interaction (Table 2. $P > .176$; $\eta^2 < 0.045$), no
9 main effect of group (Table 2. $P = .365$; $\eta^2 = .021$), or main effect of time (Table 2. $P > .139$; $\eta^2 < .055$).

10 [Insert Table 2 Here]

11 *Functional Fitness*

12 For Chair Stand performance, Chair Sit & Reach left, Back Scratch, TUG, HGS and 4m gait
13 time there was no Group*Time interaction (Fig 2A, D-G. $p > .052$; $\eta^2 < .089$), no main effect of group
14 (Fig 2A, D-G. $p > .320$; $\eta^2 < .024$) and no main effect of Time (Fig 2A, D-G $p > .381$; $\eta^2 < 0.020$).
15 Similarly, for 4m gait time there was no Group*Time interaction (Fig 2I. $p = .075$; $\eta^2 = .075$) and no
16 difference between groups (Fig 2I $p = .939$; $\eta^2 < .001$). However, irrespective of group, 4m gait time
17 was reduced following the intervention period (Fig 2I $p = .001$; $\eta^2 = .239$).

18 For arm curl performance, Chair Sit & Reach right side and 6MWT, there was a significant
19 interaction (Fig 2B, C, J. $p < .024$; $\eta^2 > .118$). Pairwise comparisons indicated that prior to the
20 intervention, Chair Sit & Reach right performance was better in control group compared to the
21 intervention group (Fig 2C. $p = .009$; $g = .84$). There was no difference in arm curl performance prior to
22 the intervention period between the intervention and control group (Fig 2B. $p = .144$; $g = .49$). Following
23 the intervention period, the number of arm curls completed in the control group had reduced (Fig 2B.
24 $p = .019$; $g = .34$) but had increased in the intervention group (Fig 2B. $p = .022$; $g = .32$). Pairwise
25 comparisons further indicated that 6MWT distance increased following completion of the intervention
26 (Fig 2J. $p = .005$; $g = .34$), to a level that was greater than the control group (Fig 2J. $p = .013$; $g = .64$).

1 There was no difference in 6MWT distance between the groups prior to the intervention period (Fig
2 2J. $p=.480$; $g=.31$). Performance in the short serve test improved following the intervention ($P=.008$;
3 $g=.910$).

4 [Insert Figure 2 Here]

5 *Coincidence Anticipation Time*

6 For VE at 3mph there was no Group*Time interaction (Fig 3B. $p=.161$; $\eta^2=.049$), no main
7 effect of group (Fig 3B. $p=.193$; $\eta^2=.042$) and no main effect of time (Fig 3B. $p=.460$; $\eta^2=.014$). For
8 CE at 3mph there was no Group*Time interaction (Fig 3A. $p=.161$; $\eta^2=.049$), however CE was lower
9 in the control group (Fig 3A. $p=.002$; $\eta^2=.224$), and irrespective of group, was reduced following the
10 intervention period (Fig 3A. $p=.019$; $\eta^2=.131$). For AE at 3mph there was a significant interaction
11 (Fig 3C. $p=.015$; $\eta^2=.139$). Pairwise comparisons indicated that prior to the intervention
12 performance in the control group was better than that of the intervention group (Fig 3C. $p=.003$;
13 $g=.96$). Furthermore, the intervention was effective in improving AE (Fig 3C. $p=.005$; $g=.57$).

14 For VE at 8mph there was no Group*Time interaction Fig 3E. $p=.116$; $\eta^2=.060$) and no main
15 effect of group (Fig 3E. $p=.397$; $\eta^2=.018$). However, VE was reduced following the intervention
16 period (Fig 3E. $p=.028$; $\eta^2=.115$). For both CE and AE measured at 8mph there was a Group*Time
17 interaction (Fig 3E&F. $p<.002$; $\eta^2>.097$). Pairwise comparisons indicated that CE and AE
18 performance were better in the control group (Fig 3E&F. $p<0.029$; $g>.70$), and in both cases were
19 improved following the completion of the intervention (Fig 3E&F. $p<.002$; $g>.68$).

20 [Insert Figure 3 Here]

21 *Self-Efficacy for Exercise, Wellbeing & Benefits and Barriers to Exercise*

22 For SEE there was a significant Time*Group interaction (Fig 4A. $P=.006$; $\eta^2=.179$). Pairwise
23 comparisons indicated that prior to the intervention period, SEE was higher in the control group (Fig
24 4A. $P=.005$; $g=.926$), but there was no difference between groups at the end of the intervention (Fig
25 4A. $P=.346$; $g=.298$). SEE increased following the intervention (Fig 4A. $P=.004$; $g=.503$), with no
26 effect in the control group (Fig 4A. $P=.289$; $g=.271$). For WEMWBS there was no Group*Time

1 interaction (Fig 4B. $P=.381$; $\eta^2=.020$), no main effect of time (Fig 4B. $P=.680$; $\eta^2=.004$) and no
2 main effect of group (Fig 4B. $P=.210$; $\eta^2=.040$).

3 For the total score of the EBBS there was no significant Time*Group interaction (Fig 4C.
4 $P=.132$; $\eta^2=.062$), no main effect of group (Fig 4C. $P=.310$; $\eta^2=.029$), or no main effect of time (Fig
5 4C. $P=.596$; $\eta^2=.008$). Similarly, for the barriers sub-scale, there was no significant interaction (Fig
6 4C. $P=.772$; $\eta^2=.002$), no main effect of group (Fig 4C. $P=.251$; $\eta^2=.036$), or no main effect of time
7 (Fig 4C. $P=.772$; $\eta^2=.002$). For the benefits sub-scale, there was a significant Time*Group
8 interaction (Fig 4C. $P=.016$; $\eta^2=.151$). Pairwise comparisons indicated that irrespective of time,
9 perceived benefits did not differ between groups (Fig 4C. $P>.162$; $g<.464$). However, perceived
10 benefits increased following the intervention (Fig 4C. $P=.012$; $g=.582$), with no effect in the control
11 group (Fig 4C. $P=.356$; $g=.213$).

12 [Insert Figure 4 Here]

13 **Part 2: Lived Experiences of Shuttle Time for Seniors**

14 Questions were based on developing an understanding of three areas 1) interests and expectations
15 of the programme, 2) experience of the programme, and 3) hopes for the future. The topic, followed
16 by the main themes and sub themes, if relevant, are presented below. A summary of the analysis is
17 presented in Figure 5 and a more detailed coding tree presented in supplementary file 4 (SF4).

18 [Insert Figure 5 Here]

19 *Interest and expectations of the programme*

20 When asked to discuss their interest and expectations for the programme, three themes (prior
21 experience, the opportunity, social persuasion) for interest in the programme were identified and two
22 for expectations of the programme (perceived physical and psycho-social benefits, unsure).

23 **Theme 1: Prior experience**

24 This theme encapsulates participants positive experience of a racquet sport, being involved in a
25 previous project which they enjoyed and felt the value of, or lack of experience with badminton, which

1 drove interest for the project. In group two, who perceived to be of higher ability, prior experience of
2 badminton was commonly shared, but this was a long time ago or of other racquet sports (i.e., tennis)
3 which they believed would help. In other groups, most had limited experience or had never played
4 badminton. For these, it was an opportunity to try something new, with some reflecting how they
5 wished they had played when they were younger.

6 *'Well I might have played five games of badminton in my whole life but last time was 30, 40*
7 *years ago. So badminton was all new. But obviously I played tennis, so I got it. I can can*
8 *hit a ball ...'* (2.4, M)

9
10 *'I thought, I've never played badminton. And I thought, well, that's a, that's a good reason*
11 *to do it. Why not do it and find out whether, whether you enjoyed it or not. And the actual*
12 *program, I actually enjoyed it and would actually do fancy taking it off'* (3.1, M)

13

14 **Theme 2: Physical and psycho-social opportunity and perceived benefits**

15

16 The opportunity to meet new people, learn a sport/skill and have fun as well as to commit to
17 something, or provide a kick starter to that commitment, was felt similarly amongst groups.
18 Particularly the characteristics of the group were important, believing it to be an opportunity to join
19 likeminded people at similar levels to them. Particularly participants shared how without this
20 opportunity they would not have been able to take up badminton on their own. For individuals in
21 group 1 and 3 specifically, the opportunity for physical exercise was commonly shared, explaining
22 how it would provide a good 6-8 weeks of exercise.

23 *'this looked like an ideal opportunity to meet people of a similar age, similar ability, um, and*
24 *sort of see, enjoy the social side of things perhaps. Um, cuz I was always afraid to try and*
25 *join any club age wise, not good enough and not fit enough. And whereas joining these*
26 *people, perhaps they're a similar ability, similar age group and, um, you know, similar,*
27 *similar fitness levels and, uh, I felt more comfortable with that side of things'* (3.4, M)

28

29 *'Exercise for me, I thought, well, it'll be a good six or eight weeks of exercise'* (1.4, F)

30

31 Given that participants were interested in the programme for the perceived physical and
32 psycho-social opportunity, their expectations of the programme also focused on the physical and
33 psycho-social benefits. For group 2 specifically, the physical and psycho-social benefits were to
34 relearn or reconnect with badminton. While participants reported perceived benefits, it was

1 commonly shared that they were not quite sure on how this would be done within the specifics of the
2 programme.

3 *'I found it a focus to come back to doing things and I thought, well yes, I used to do that. And*
4 *um, I found it really encouraging from that point of view. I wouldn't have done it on my own.*
5 *So I would never have played badminton again... It fell apart in days gone by simply cuz my*
6 *life changed, the people I used to play with. You know, I went to live and worked abroad, so*
7 *couldn't play with them. Um, so it was a reconnection that I thought, oh yeah, that'll be fun'*
8 *(2.6.M)*
9

10
11

Theme 3: Social persuasion

12 For some individuals, they were encouraged to take action by social persuasion by
13 individuals who either asked them to do it with them, encouraged them to go along with them or
14 signed them up.

15 *'Well, for me, [friends name] asked me if I'd, uh, I'd do it cause they were looking for, for*
16 *people and it was like a bit of a kickstart cause I hadn't done anything for nearly a year' (1.5, F)*
17

Programme Evaluation

18
19 Discussions around what participants thought about the programme were positive and led to
20 three main themes (1. Programme delivery, 2. Perceived impact of the programme on their
21 wellbeing, 3. Reinforcing and disabling factors; ability, opportunity).

Theme 1: Programme delivery

23 This theme encapsulated all aspects related to participants experiences of what was
24 delivered and how this was delivered. This theme contains three sub-themes (design &
25 implementation appropriate for over 60's, coach behaviours: a need for autonomy vs direct
26 instruction, and practical issues).

Subtheme 1: Design & implementation appropriate for over 60's

28 Considering the design and implementation, all groups felt that the programme was
29 appropriate and well-structured for over 60's. Participants reported that there was a slow build up
30 which was appropriate, felt that the programme was well designed for those who had not played
31 before, but that the balance was right. Constrained match play was perceived to be the best part of

1 each session, but participants recognised the benefits of exercises and activities transferring to
2 constrained match play. Participants would have liked the session to be extended to allow longer
3 time for match play, however, they reflected that this may not be inclusive for all.

4 *'Yeah. Cause I, well I quite liked the way it worked over the eight weeks, the slow build up*
5 *and we got better and better and then I thought by the state time, the eight weeks was over,*
6 *we were all ready to start to play games' (3.3, F) 'I, I actually thought it was well structured*
7 *that people, they had a group of over sixties come in and had no real idea about fitness*
8 *levels. And so people were able to grade themselves on this and think, well, and then slowly*
9 *get into it and Okay. Yeah. And then try and hit the shuttle to the back of the court. And I,*
10 *I, for could never manage it, but, uh, it's that kind of level there. You slowly realized that,*
11 *yeah, I can do this. So I mean, I am quite capable of doing this' (3.1, M)*

12 *'...it all built up. I enjoyed every week... I did like playing the games at the end, but then at*
13 *the beginning I probably wouldn't have been able to have played those games' (2.3,F)*
14 *Thought maybe, you know, if you had a longer session you you might actually actually get a*
15 *bit more ba..badminton in as well. I know you were trying, you know, generally it was like*
16 *good half, of the hour was spent various exercises and warmups and stuff like that and yeah,*
17 *the actual playing was was 10, 15 minutes. You know, and I think you, you could have done*
18 *with a longer, a longer, you know, may you maybe an hour and a half session It might actually*
19 *get, get yourself a good off hour play every time' (2.4, M) 'Difficult with an hour and a half*
20 *sessions, again if you make it more inclusive, include at the bottom end. Some people with*
21 *those health issues, would be struggling' (2.1, M)*

22
23
24 For group 3 only, the dose was considered to be a 'good hours' worth of exercise' reporting
25 activities led to sweating, muscle work and hand eye coordination. Specifically, participants shared
26 how the warm up made them out of breath but it was self-paced and they could stop if they needed
27 to.

28 *'... when we were throwing the shuttle cock cuz it was giving you, making these muscles*
29 *work with both hands, you know, I thinking, oh this is hard work, you know, I'd rather have*
30 *a rack <laugh> in back and we were really pushing it, we were all sweating, weren't we'*
31 *(3.6, M)*

32
33
34 *Subtheme 2: Coach behaviours: a need for autonomy vs direct instruction,*

35
36 Coach behaviours were discussed in how the intervention was delivered. Groups felt that the
37 coaches were skilled physically and interpersonally but depending on their ability they experienced
38 different input or wanted different input from the coach. Group 3 who perceived themselves to be
39 less able reported how they received demonstration and instruction. Group 1 and 2 wanted more
40 direct specific technical instruction from the coaches alongside wanting more information on why
41 they were doing the activity.

1 *'He's so personable. He is. And that is really important without being patronizing because*
2 *younger people don't always engage, engage that Well and because they did jokingly say*
3 *when we first came in, uh, there will be some trainees and, but they were very good as well*
4 *actually. I thought they were all very sort of pleasant' (1.6, F)*
5

6 *'No, no, that's right. I think, I think the ambition, um, of the, of the programme I think, I think*
7 *it was, it was about right to be honest. I think it would've, it obviously would've been nice to*
8 *have sort of started at week one and by week eight become a super duper badminton player.*
9 *But I think, I think that's a bit too ambitious. But I think that certain, certainly it would've, um,*
10 *certainly I would've um, welcomed a bit more technical. Yes. Input is, I think that's what you're*
11 *saying in terms of, cause I, my back hand's useless really about and I would've like' (3.6, M)*
12

13 There were also differences between groups related to autonomy and direct instruction. For
14 group 3, they reported the importance of choosing the court and having the choice to stop when they
15 needed to. This was recognised by group 1 and 2 but they identified how groups stayed together
16 and thus they wanted to be directed to circulate and play different people.

17 *'Yeah. I quite like the fact that we, yeah, we stopped, we, we picked the courts. Yeah. And*
18 *I haven't got a clue where I fit into everything, but, um, I was a bit, I was kind of happy with*
19 *myself because I could, I could still run and I could hit things. Maybe not all the time, but*
20 *we were all about the same level really. So it wasn't a big problem. No. And there's a couple*
21 *that were pretty good, especially with the drop shops and I think done that again, you, I*
22 *should realize that' (3.6, M)*
23

24 *'Yeah. And also maybe circulating more, um, I was on the bottom court but we didn't play*
25 *with the people next door to us so we became a self-selecting small group. I think that could*
26 *have been mixed up a bit' (2.6, M)*
27

28 *Subtheme 3: Practical issues*

29 All groups outlined issues with the delivery specifically related to acoustics and too many
30 individuals on a court. It was felt that it was difficult to hear the instructions and information due to
31 the acoustics of the room.

32 *'I think there were one or two sort of practical issues that, that could perhaps be ironed out*
33 *for a future program. For example, the, the number of courts that we had wasn't quite enough*
34 *for the number of people that we had. So, you know, there was a certain amount of waiting*
35 *to go, you know, cycling onto the, onto the court and things like that, which was mildly*
36 *frustrating. Nothing, nothing major, but just mildly frustrating. So I think if the, you know, there*
37 *were quite a lot of people on the programme altogether and, and um, we could have probably*
38 *done with a few more courts to, to uh, optimize the thing from that point of view' (2.5, M)*
39

40 *'Um, you know, there may be more than four people to a court, you know, explaining a little*
41 *bit more. And um, also the, um, acoustics in the badminton court make it very difficult for you*
42 *to hear what's being said. And quite often we were like, What, what did you say? What did*
43 *you say? And I dunno how you get around that. I really don't. Yeah, I don't' (1.5.F)*
44

1 Furthermore, for those who felt more able they would have liked longer in the session (1.5
2 hours) to enable them more time for match play and a programme that extended beyond 8 weeks,
3 ideally 10-12 weeks, where there was more specific focus on the development of technical
4 competency and further understanding of competitive match play rules.

5 *'Thought maybe, you know, if you had a longer session you you might actually actually get a*
6 *bit more ba..badminton in as well. I know you were trying, you know, generally it was like*
7 *good half of the hour was spent various exercises and warm ups and stuff like that and yeah,*
8 *the actual playing was was 10, 15 minutes. You know, and I think you, you could have done*
9 *with a longer, a longer, you know, maybe an hour and a half session. It might actually get,*
10 *get yourself a good half hour play every time' (2.4, M)*

11
12
13 **Theme 2: Perceived Impact of the Programme on Wellbeing**

14 Participants reported perceived changes to wellbeing as a result of the programme. These
15 factors were interlinked and included the perception that their physical and cognitive ability had
16 improved (e.g. reaction time, hand eye coordination, skill learning and movement ability), affective
17 responses (e.g. felt the benefits to the body, enjoyed it and was hooked, increase in self-efficacy,
18 feeling comfortable) and social benefits (e.g. meeting new people). For example, having the
19 opportunity to meet new people and play with similar and likeminded people created an environment
20 where individuals felt comfortable and could have a fun and enjoyable experience. Consequently,
21 due to the environment created, they were able to play in a way which facilitated beliefs that they
22 had improved their physical and cognitive ability as well as feeling the benefits to the body, which
23 contributed to enjoyment, being hooked and increased confidence.

24 *'Yeah, I mean I certainly feel as I can hit the badminton shuttlecock now. Um, whereas*
25 *before when I've had to go, um, I'd miss it an awful lot of times, and my reaction seems a*
26 *lot better. The speed of reaction, hand eye coordination seems better' (3.4, M). 'Yeah. I think*
27 *I'm, uh, a bit fitter and uh, maybe a bit more confident about, uh, you know, uh, playing*
28 *badminton' (3.5, M). 'You know, um, and also thinking about the other physical things where*
29 *we're doing with the knee, going down and practicing that is right. Obviously you've gotta get*
30 *down to catch it if it's coming down too low. And I'd probably think I'd just do it from here, but*
31 *now I gotta think a little bit harder. Okay. I might miss it, but at least I'm thinking about where*
32 *it's gonna be and, and where I've got to be. So I suppose it's a mental thing that's, uh, running*
33 *through at the same time as the physical' (3.6, M)*

34
35 *'First. I mean I came out of each session thinking, oh I've used the body a bit and I'd rather*
36 *enjoyed that and I'm looking forward to coming back again. Yeah. That was my overall sense*
37 *And presumably cuz we all turned up again, that was the theming of other people' (2.6,*
38 *M). 'Yeah, I think, I think, you know, most of us or, well I can't speak for, but for myself I felt*
39 *more positive about badminton at the end of the eight weeks than I did at the beginning. You*

1 *know, I felt quite positive at the beginning but I felt better at the end cause we'd been sort of*
2 *laying around and doing different things' (2.5, M)*
3

4 **Theme 3: Reinforcing and disabling factors: ability and opportunity**

5

6 Participants frequently discussed ability and opportunity as processes of change (reinforcing
7 and disabling factors). Early positive experiences or lack of fitness and the diversity of the ability in
8 over 60's was seen as either an enabler or disabling factor. When ability was a disabling factor, the
9 opportunity to be able to rest as needed and join back in when ready was important as well as playing
10 those of a similar ability, which meant the game could still be enjoyable. Furthermore, the way the
11 opportunity was provided created a low pressurised environment with the positive changes
12 considered to be due to the opportunity provided where they could play with similar ability, the groups
13 were unformed, the environment being inclusive and supportive, people were at the same level
14 and/or starting together, and autonomy provided. People who were more able also shared the
15 experiences they had observed of others less able in their group with admiration.

16 *"But you could stop if you needed to. Cause there were a couple of ladies who were on our*
17 *court who got out of breath quite quickly and they would just go and sit down and then join*
18 *in when they were ready and it worked really' (3.1, M)*
19

20 *'And, and I think that's been one of the nice things about this, you know, I don't think, I*
21 *wouldn't imagine anybody has felt, you know, embarrassed by their level (2.5, M) 'it's been*
22 *very inclusive' (2.6, M). 'It's been very, been very supported, it's environment really. And*
23 *everybody's probably enjoyed it from that point of view. So, um, yeah, it's, it's, I just wanted*
24 *to pick on that point about the department' (2.5, M)*

25 *'I think the good thing about badminton is as long as you are playing somebody of similar*
26 *ability, you can enjoy the game no matter what ability'. (1.2, F)*
27

28 *'I think it's just sort of a pretty non pressurised, uh, environment as well. I mean, you come*
29 *into it, you come into it on the basis that you, you're sort of being assessed for your fitness,*
30 *which is sort of an individual thing. And then you gradually sort of, uh, melt into the rest of*
31 *the group as it were, sort of thing. So it's just, it's a sort of an easy way of getting to interact*
32 *with other people and get to know other people really' (2.5, M) Mm-hmm. <affirmative>. (2.3,*
33 *F) 'Cause it's not, there's no sort of initial meeting pressure as it were. You know, you, you*
34 *sort of gradually sort of introduced to the rest of the group in, in a, in a sort of a soft way*
35 *really. So I think, I think that appeals to a lot of people. It appeals well, it appeals to me, let's*
36 *put it that way. can't speak for anybody else, but I think it's a sort of, um, it's a, it's a pleasant*
37 *low pressure way of getting into an environment and a group that's, you know, positive. So I*
38 *think it's, um, it's got a lot going for it. This kind of, this kind of approach to bringing people*
39 *into sport, I think is a good thing. And, and, and using the uh, let's say the entree of, well let's*
40 *see what your physical fitness is to start with and then what you do a programme and then*
41 *we'll see it at the end. I think that's an appealing, appealing prospect, appealing idea for a lot*
42 *of people' (2.5,M).*
43

1 *'Really interesting, I think the principles that sort of, um, made it a successful exercise for us.*
2 *I think we are all relatively, um, confident people [referring to the people in the group*
3 *interview], but I think, I think this kind of process enables people who are less confident to*
4 *move into a group that's not already formed. Because I think that's what puts a lot of people*
5 *off joining sports clubs. You know, they're, if they're, if they're relatively middle, if they, if*
6 *they're not particularly sociable types and haven't got a lot of friends or whatever, then it's*
7 *difficult to just go along to a football club or whatever and say I wanna play football, play your*
8 *team sort of thing. It's perhaps not a very good example, but I just, the process of moving*
9 *into a new social environment is quite stressful for a lot of people. So I think coming into or*
10 *having available to you or explained to you that the, that what is available is, is is basically*
11 *an unformed group. So everybody's in the same boat, everybody's just sort of coming along*
12 *with their own agendas or whatever requirements or motives and, and um, and therefore*
13 *everybody's in the same boat and everybody sort of has a chance to get into it more easily,*
14 *if you see what I mean. It's, it's, it's, it's, it's uh, you know, I think one of the benefits is, as*
15 *you say, you know, the social grouping that you get, the, the interactions is pleasant, pleasant*
16 *enough, you know, to, to, to meet new people and all that sort of thing. Um, but in the real*
17 *world as it were though, moving into those kind of new social settings is more, more difficult.*
18 *So I think this is an easy way of doing that because the groups aren't formed and it's, it's*
19 *something new for everybody. Well, apart from this little group here, we do go walking*
20 *together. But, but generally speaking I think it's a sort of, um, easy opportunity to get into*
21 *something without having the, the sort of stress involved' (2.5, M)*
22

23 *Hopes For the Future*

24 Two common themes were identified related to hopes following the programme 1: Want to
25 continue with likeminded people, 2. Badminton infrastructure.

26 **Theme 1: Desire to continue with likeminded people**

27 All groups reported enjoying the experience, felt they were in a better position with playing than at
28 the start and wanted to continue with likeminded people. They felt that continuing with likeminded
29 people provided an environment they could be comfortable in practicing or pushing themselves
30 further as well as being able to accommodate each other. There were some differences in what they
31 wanted to achieve from these further sessions, some wanted more informal sessions whilst others
32 wanted a longer duration programme which focused specifically on playing a game including
33 technical coaching and scoring. This was prominent in individuals who reported in the programme
34 evaluation the need for more direct specific technical instruction (group 2) and for those in group 1
35 and 3 who had no prior playing experiences but felt they had got to the stage to start to play a game.

36
37 *'I don't think I could go in and join an existing badminton group cuz I feel, I feel as though I*
38 *wouldn't be up to speed. No. But I would definitely like to go somewhere where I would feel*
39 *comfortable in practicing. So rather than a game per se... I would just like to just hit it and,*
40 *and do' (1.6, F)*

1
2 *'I think for me, other people might not agree with this, I would like it to be 10 weeks. So we*
3 *got to the stage, we got to at the end of the eight weeks and then the next two weeks we*
4 *could really play, you know, get to know the rules really well in ' (3.3, F). 'the actual rules. I*
5 *mean, someone like me have never played it, you know, totally never played it. Uh, I even at*
6 *the end, I really didn't know the rules. Uh, yeah' (3.1, M).*

8 **Theme 2: Badminton infrastructure**

9
10 Participants, particularly of group 2, discussed the infrastructure of badminton as a sport targeted for
11 older adults in comparison to tennis or golf. They discussed the challenges of having to find a person
12 to play with, age-appropriate leagues, having to book a court, knowing where to play and more. They
13 discussed how in tennis and golf this infrastructure with a social network exists. They reported a
14 hope that a badminton infrastructure could be developed like comparative sports.

15
16 *'... You don't seem to get the same badminton club network do you, as you do tennis clubs*
17 *for example, you, you know, there's, there isn't a sort of, uh, badminton club circuit Is that*
18 *really that you could say? I mean, Badminton tends to be, um, using leisure, leisure club*
19 *facilities or something like that, you know, and, and maybe a a a badminton group has*
20 *access to some facilities at the leisure center or something like that. But they don't, they*
21 *don't actually have their own facilities. They don't actually have their badminton club*
22 *facilities, you know, I mean we always, we, I been played, I've played quite a reasonable*
23 *amount of badminton, I suppose 30 or 40 games I suppose, something like that. And um,*
24 *we always say, you know, oh we must go down to [Place] and you know, get some sort of*
25 *masterclass or something like that, you know, to improve our game. I mean, it, it probably*
26 *would make much difference to us at our age. But I mean it's, it's just, I mean that the only*
27 *thing you can think of, you know, is the only thing you can pinpoint in badminton..., is Milton*
28 *Keens is the national center, you know, and he watched the, I mean we went to the um, we*
29 *went to the national championship so, um, two or three weeks ago at uh, at the arena in*
30 *Birmingham, the badminton championships. You know, try and pick up a few tips. But I think*
31 *apart from, um, apart from things like that, there isn't actually what, I don't know, well maybe*
32 *there is, but it's just, I'm not aware of it. But I, there doesn't seem to be a kind of a, a network*
33 *of clubs or, um, you' (2,5,M). 'You mean a support that has a social surround?'(2.6, M). 'An*
34 *infrastructure, I suppose..what would you do?...how would you align yourself to a, a club?*
35 *Where would you go? What would you, how would you kick off? You know' (2.5, M).*
36
37

38 **DISCUSSION**

39 PA promotion is at the foundation of public health strategy to promote healthy ageing (Beard
40 & Bloom, 2015; Cruz-Jentoft et al., 2019), where age-appropriate group-based exercise, using sport
41 as a vehicle, may be effective for improving physical and psychosocial health (Duncan et al., 2022;
42 Gayman et al., 2017). Whilst those that continue to play sport across the life course typically elicit
43 healthier ageing trajectories (Oliveira et al., 2023), sport as a PA opportunity for older adults is not

1 widely explored and research focused on developing and evaluating the efficacy of age-appropriate
2 sports interventions is sparse (Jenkin et al., 2017). The present study addresses this gap in the
3 literature and evaluated the effect of STS, an introductory 8-week badminton intervention designed
4 specifically for older adults, on functional fitness, wellbeing and badminton specific skill. Furthermore,
5 thematic analysis of focus groups was used to understand the lived experiences of undertaking the
6 STS. Results of the present study demonstrate that upper body strength, aerobic capacity,
7 coincidence anticipation time and short serve performance were improved in individuals that
8 completed the STS intervention. As such, these data infer that STS is effective in improving physical
9 and cognitive facets important for healthy ageing, where STS may provide an initial platform to elicit
10 broader and more pronounced healthy ageing benefits through sustained badminton engagement.
11 STS is the first badminton specific intervention designed for older adults, where the age-appropriate
12 opportunity to participate in badminton, with likeminded people of similar ability were primary
13 motivators to engagement. The programme was perceived by participants as appropriate and well-
14 structured for the target population, with participants perceiving improved physical and cognitive
15 ability, affective responses, social benefits and increased self-efficacy following completion. Despite
16 a willingness to continue playing badminton, participants indicated that further coaching on technical
17 and tactical elements would facilitate longer term engagement but also highlighted the lack of
18 badminton infrastructure as a primary barrier.

19

20 *Effect of STS on Physical & Cognitive Function*

21 Studies examining the health benefits of recreational badminton are sparse and the available
22 literature specific to children and young adults (Cabello-Manrique et al., 2022). Results of the present
23 study indicate for the first time that the physiological, biomechanical and cognitive demand of
24 recreational badminton can be harnessed to promote healthy ageing by enhancing physical and
25 cognitive function. Furthermore, such benefits can be recognised in a reasonably short time frame,
26 with only a single weekly session. These findings provide support more broadly for the value of
27 engaging or re-engaging with sport as an opportunity for promoting healthy ageing and extend the
28 evidence base which is largely specific to soccer (Duncan et al., 2022).

1 Participants that completed STS increased upper body strength, aerobic capacity and
2 coincidence anticipation time, with such facets of physical and cognitive performance underpinning
3 the completion of activities of daily living (ADL) and differentiating between capability of completing
4 advanced and basic ADL (Demekong et al., 2022). Moreover, muscular strength, aerobic capacity
5 and reaction time are direct markers of health, where an age-related reduction in these components
6 is linked to morbidity, increased fall risk and all-cause mortality (Fung et al., 2020; Newman et al.,
7 2006; Pacifico et al., 2020; Wang et al., 2016). Such findings should be contextualised with respect
8 to the purpose of STS, which is designed to be an age-appropriate introduction-reintroduction to
9 badminton to provide impetus for longer term badminton engagement in which there is the potential
10 for further health benefit. For example, data from the Copenhagen City Heart Study indicated that
11 engagement with badminton increased life expectancy by 6.2 yrs compared to a sedentary group
12 (Schnohr et al., 2018). However, to realise the wider potential of STS, these findings need be
13 contextualised with respect to barriers and enablers to initial and sustained engagement.

14

15 *Engagement & Sustainability*

16 Although particularly lacking for sport, there is a wealth of evidence supporting the beneficial
17 effects of well-designed exercise or PA interventions for promoting healthy ageing (Chou et al., 2012;
18 Vogel et al., 2009b). Whilst the benefits of PA are without question, the wider and sustained impact
19 of such interventions are limited by their effectiveness to incite behaviour change. As such, focus
20 groups were used to understand barriers and enablers to engagement with STS and longer-term
21 engagement with badminton upon completion of the programme. Whilst there are several theories
22 used to explore behaviour change in a PA context, the Behaviour Change Wheel (BCW) provides a
23 synthesis of many previously established frameworks (Michie et al., 2011). Central to the BCW is
24 the Capabilities, Opportunities, Motivations, Behaviour (COM-B) model (Michie et al., 2011) which
25 is recognised by the National Institute for Health & Care Excellence as a key framework for
26 understanding and supporting behaviour change (NICE, 2014). The measured effects and long-term
27 impact of STS is based on developing Capabilities, Opportunities and Motivation across the different
28 levels of the BCW.

1 The small number of studies that have evaluated the effects of older adults engaging or
2 reengaging in sport for promoting facets of healthy ageing typically focus on the impact of match-
3 play (Arnold et al., 2015; Duncan et al., 2022; Reddy et al., 2017). Whilst match-play may be adapted
4 to better suit the capability of the population and to mitigate injury risk (e.g. walking football) (Arnold
5 et al., 2015), a lack of perceived capability and self-efficacy are commonly cited barriers and enablers
6 respectively to healthy PA behaviours (Gray et al., 2016b; Lees et al., 2005) and may be specific
7 barriers for engagement in age-appropriate sport which is match-play focused given then need for
8 some degree of technical skill competency. There is a distinct lack of evidence evaluating the impact
9 of interventions designed to introduce/reintroduce older adults into sport, where the focus is on
10 developing competency for sustained engagement. For some participants engagement in STS was
11 driven by positive experiences of previously playing badminton or other racquet sports, where theory
12 suggest that if such experiences are associated with positive perceived affective responses, this can
13 be a driver for behaviour (Brand & Cheval, 2019). STS provided enablement, offering a physical
14 opportunity to engage in badminton and provided training that developed physical and psychological
15 capability. This in combination with demonstrated affective responses during the sessions, where
16 evidence suggests that pleasure or displeasure of PA and exercise experiences can influence
17 subsequent PA behaviour (Ekkekakis, 2017), meaning that STS may provide an important basis for
18 longer term behaviour change.

19 Data from the present study further indicate that STS was effective for improving self-efficacy.
20 Self- efficacy has been shown to be an important driver to sustained healthy PA behaviours for older
21 adults (McAuley et al., 2003). The increased self-efficacy can in part be explained by improved
22 perception of capability and positive affective responses, where according to Bandura (Bandura et
23 al., 1997), positive task performance experience and physiological feedback are important influences
24 of self-efficacy. In addition, thematic analysis identified several other factors linked to motivation that
25 likely influenced engagement in STS and indicate that the programme may be useful to provide a
26 platform for long-term behaviour change. These factors can be linked to basic psychological needs
27 that form part of self-determination theory (SDT) (Teixeira et al., 2012), which has been used as a
28 model for behaviour change in a PA context (Fortier et al., 2007). Primary themes underpinning

1 engagement were the perception of participating with likeminded people of similar ability and
2 psychosocial benefit, where perceptions of personal connection (relatedness) in an empathetic and
3 positive environment is a key driver of behaviour (Teixeira et al., 2012). In support, previous work
4 indicates that social capital relates to objectively measured PA levels in older adults (Ho et al., 2018).
5 Furthermore, positive coach perceptions, the perception of an optimally challenging task, and the
6 option to select differentiated tasks to match perceived capability where themes identified by the
7 intervention group which link to the basic psychological needs of competence and autonomy outlined
8 in the SDT (Teixeira et al., 2012), cumulatively resulting in a positively engaging environment for
9 participation.

10 In accordance with the transtheoretical model of behaviour change that purposes PA
11 behaviours can be mapped to a cycle of six phases (Prochaska & Velicer, 1997), STS may be an
12 effective tool in aiding the transition of individuals in the 'Preparation' phase to the 'Action' phase.
13 However, participants that completed the intervention perceived barriers to sustained engagement
14 with badminton, which may limit the later transition to 'Maintenance' which is typically recognised
15 after six months of sustained behaviour (Pekmezi et al., 2010). Of note, a lack of badminton
16 infrastructure was identified, where more specifically participants outlined opportunity and capability
17 barriers such as finding likeminded people to play with, age-appropriate leagues, knowing where to
18 play, and understanding how to book a court. Although STS was effective for improving competency
19 and self-efficacy for badminton, participants still perceived these as barriers to engagement in
20 already established community-based badminton initiatives. To overcome these issues, providing
21 physical opportunity for the group formed following completion of STS to continue engaging with
22 badminton may be beneficial. Furthermore, participants identified a need to now focus further on
23 developing technical and tactical knowledge of badminton, where extending STS, or development of
24 an intermediate programme focusing on these elements, may evoke further increased perception of
25 competency and self-efficacy needed for engagement in community-based programmes.

26

27 *Programme Evaluation*

1 As per the principles by which STS was designed, participants perceived that the programme
2 was appropriate for the target age group and for those with different levels of physical and badminton
3 ability, that sessions were well structured, and that progression occurred at an appropriate rate.
4 Participants outlined the importance of sessions being facilitated by physically and interpersonally
5 skilled coach that recognises the needs of the older adult population, which is in line with previous
6 work suggesting instructors' characteristics have influence participants' attendance to exercise
7 classes (Hawley-Hague et al., 2014). Participants also made suggestions for how STS may be
8 improved. The inclusive nature of the intervention was based on differentiating planned tasks by
9 ability, this was typically achieved by manipulating the challenge on each court and affording
10 autonomy to participants in selecting the level of difficulty. After explanation and demonstration,
11 participants were able to choose the task that best suited their perceived capability. Evidence shows
12 that autonomy is important for developing motivation (Bandura et al., 1997), and the value of this
13 approach was also recognised by participants in the present study. However, this resulted in the
14 formation of 'groups' and participants indicated more overt direction to circulate between groups may
15 have been beneficial. Furthermore, groups identified that more explicit information regarding the
16 broader purpose of the tasks and further focus on coaching technique would be useful. Some of
17 these potential areas for development can in part be attributed to the size of the group, length of the
18 session and poor acoustics in the room which were identified by participants. Where space allows,
19 future delivery of STS should consider limiting participant number to four individuals per court.

20

21 *Limitations & Future Direction*

22 Despite the study offering important new insight into the efficacy of a badminton specific
23 intervention designed to promote healthy ageing, it is not without limitation. Initially, given
24 participant's availability to be able to commit to completing the 8-week group-based intervention, a
25 quasi-experimental approach was employed rather than random group allocation. However, whilst
26 randomised control trials are more robust, statistical analysis of the data from the final sample
27 revealed that the groups used in the study were matched for age, body composition and baseline
28 functional fitness. Furthermore, measures of cognitive function were specific to coincidence

1 anticipation time, whilst this is relevant to badminton and is important to every day cognitive function,
2 the study did not consider the impact of STS on other measures of cognition, such as executive
3 function, that has been shown to deteriorate with increasing age (Murman, 2015). Furthermore,
4 coincidence anticipation time recorded by swinging a badminton racquet provided a sport specific
5 assessment which was deemed appropriate for the intervention group, but the results may not be
6 directly comparable to the button press method used by the control group. Additionally, exploring
7 further health measures such as blood pressure responses, blood glucose, and heart rate variability,
8 as examples, would also provide further insight into the potential health effects of STS. In addition,
9 understanding the longer-term impact of STS should be an important focus of future work to provide
10 insight into the time course of effects and the longer-term engagement in badminton following
11 completion of STS. Furthermore, the intensity of the sessions was not measured, were objective
12 assessment of perceived effort and physiological demand would help to refine the programme, with
13 understanding the variation in effort between individuals, and would help in providing a basis for
14 comparison to other activities. Given the relatively small sample size, it was not possible to evaluate
15 the impact of the intervention on those with low physical and cognitive function, where the effects
16 may be greater in magnitude and extend to other measures. Finally, whilst focus groups enabled
17 interactions to generate experiences within the group, unique individual beliefs may not have been
18 voiced using this procedure. If time would have allowed, it would have been beneficial to have offered
19 those who didn't attend the focus group discussions, an individual interview to capture their unique
20 experiences. Future work understanding the impact of coach behaviours on the delivery of STS and
21 the efficacy of designing a follow-on programme should also be considered to enhance the broader
22 potential of badminton as a tool to promote healthy ageing.

23

24 *Conclusion*

25 STS may offer a framework to promote engagement/reengagement with badminton, which
26 as per the results of the present study provides a vehicle to promote healthy ageing. Specifically,
27 STS was effective for increasing upper body strength, aerobic capacity, coincidence anticipation
28 time, short serve performance and self-efficacy for exercise. These benefits to physical and cognitive

1 function were corroborated by an increased in perceived ability as derived from thematic analysis of
2 focus groups. The STS was an enabler to participation in badminton, where the age-appropriate
3 opportunity to participate, with likeminded people of similar ability were primary motivators and where
4 the reported increase in self-efficacy for exercise may be an important driver to sustaining behaviour.
5 Participants indicated that the intervention was appropriate and well-structured for the target
6 population and made suggestions which may be useful to improve implementation of the programme
7 in the future. In light of a lack of direct evidence, the results of the present study support the
8 application of introducing older adults to sports coaching for promoting healthy ageing. However,
9 despite the specific benefits of STS and a willingness to continue playing badminton, strategies
10 including future programmes focusing on coaching technical and tactical elements as well as
11 strategies to overcome issues with badminton infrastructure are needed to promote long term
12 engagement. Consideration of these factors from a whole systems perspective is needed to increase
13 and promote sustained engagement with sport as an opportunity for promoting healthy ageing.

14

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18

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1 **FIGURES**

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3 Figure 1. Overview of Methodological Approach

4 Figure 2. The effect of Shuttle Time for Seniors on Functional Fitness [A. Chair Stand; B. Arm Curls;
5 C. Chair Sit & Reach Right; D. Chair Sit & Reach Left; E. Back Scratch Left; F. Back Scratch Right;
6 G. TUG; H. Hand Grip; I. Normal Gait Speed; J. 6MWT; K. Short Serve Test; Centre line represents
7 mean±S.E.M. N>18 for control and N>21 for intervention groups; * P<0.05]

8 Figure 3. The effect of Shuttle Time for Seniors on coincidence anticipation time [A. Constant Error
9 at 3mph; B. Variable Error at 3mph; C. Absolute Error at 3mph; D. Constant Error at 8mph; E.
10 Variable Error at 8mph; F. Absolute Error at 8mph; Centre line represents mean±S.E.M. N>18 for
11 control and N>21 for intervention groups; * P<0.05]

12 Figure 4. The effect of Shuttle Time for Seniors on Self-Efficacy for Exercise (A), Wellbeing (B) and
13 Perceived benefits and barriers to exercise (C) [Centre line represents mean±S.E.M. N>18 for
14 control and N>21 for intervention groups; * P<0.05].

15 Figure 5. Summary of the lived experiences of participation in Shuttle Time for Seniors where
16 qualitative analysis identified themes related to interests and expectations of the programme,
17 experience of the programme, and sustainability of behaviour and hopes for the future.

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1 TABLES

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Table 1. Sample Characteristics

	Control	Intervention
N =	20 (6F)	23 (8F)
Age (yrs.)	70.2±1.5	69.4±1.4
Height (cm)	168.7±1.9	172.2±1.9

F = female

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Table 2. Intervention Effects of Measures of Body Composition

	Control		Intervention	
	Pre	Post	Pre	Post
Body mass (kg)	74.8±3.3	74.0±3.3	79.1±3.0	78.9±3.1
BMI (kg/m ²)	26.0±0.8	25.8±0.8	26.6±0.8	26.4±0.8
% Muscle Mass	51.8±2.5	51.7±2.5	54.9±2.2	54.2±2.2
% Fat Mass	27.0±1.5	26.4±1.4	27.2±1.6	27.4±1.5

Data represented as mean±S.E.M; n=20 and 23 for control and intervention respectively

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