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Locked Down but Not Out: On-line Strength and Conditioning Provides A Viable Stimulus for Girls' Football Players

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ABSTRACT

Strength and conditioning is important for physical preparation in girls' association football players however, during the COVID-19 pandemic on-line "virtual" coaching replaced gym sessions. Using an retrospective observational design we aimed to quantify the internal responses from on-line and gym-based training in 27 (age 14.5 ± 0.9 yrs; stature 162 ± 6.0 cm; mass 56.8 ± 6.6 kg) girls' football players from 1 FA Regional Talent Club. Players provided session ratings of perceived exertion (RPE) via the CR-100© scale for global (sRPE-G), leg (sRPE-L), upper-body (sRPE-U), and breathless (sRPE-B), and data were analysed through mixed linear modeling. Mean sRPE for gym and on-line were approximately "hard" to "very hard" (62 and 55 Arbitrary Units [AU]) for sRPE-G, "hard" for sRPE-L (57 and 53 AU), "somewhat hard" to "hard" (54 and 42 AU) for sRPE-U and "somewhat hard" (36 and 29 AU) for sRPE-B. We observed gym based training to provide significantly higher global (6.9, 95% confidence intervals; 3.9 to 9.9 Arbitrary Units[AU]) and upper-body (7.6, 3.6 to 11.6 AU). However, differences were less than our pre-defined minimal practical difference (8 AU) and sRPE-L and sRPE-B were statistically equivalent. On-line strength and conditioning may be a viable alternative to gym-based sessions in girls' association football players.

Keywords: strength, youth, resistance training, training monitoring

INTRODUCTION

Strength and conditioning is recommended for girls' association football (soccer) players to improve fundamental movement skill, strength, and speed related physical qualities for both performance and reduce injury risk (Wright & Laas, 2016; Wright & Atkinson, 2019). Girls on a talent development pathway are exposed to structured training and competition schedules often on top of fluctuating and chaotic exposure to physical education and non-structure sport (Taylor et al., 2015). Alongside the development of movement skill competency (Lloyd & Oliver, 2012; Wright and Laas, 2016), strength and conditioning programmes in youth athletes aim to provide an appropriate stimulus to initiate positive neuromuscular or morphological adaptations (Folland & Williams, 2007; Lloyd & Oliver, 2012). As such, gym or pitch based strength and conditioning programmes have typically been employed in youth athlete development programmes. However, in response to the covid-19 global pandemic the United Kingdom (U.K) entered a state of national lockdown in March 2020, resulting in the suspension of all non-professional, grassroots and youth sports (Gov.uk. 2020). This was then extended to include access to train and play football at the grass roots/youth level (Tjønndal, 2020).

On the 23rd of March 2020, the Prime Minister for the UK government announced that the British public (minus a few exceptions) must stay-at-home for all but essential reasons. Whilst the stay-at-home restrictions were essential to prevent the spread of the virus, there was concern raised about the secondary effects of the stay-at-home restrictions on the physical and mental wellbeing of children and adolescents (Loades et al. 2020). For athletic populations reduced training load and/or an inappropriate training schedule can lead to loss of morphological and physical adaptations previously gained from training (Freire et al., 2020; Demir, Subasi, & Harput, 2021). Muscles and tendons can be impacted by detraining, with muscle strength, power, tendon stiffness and rate of force development all reduced over a 2-week period of disuse or training cessation (Sarto et al., 2020). Cohen et al. (2020) reported that a neuromuscular decline was evident in elite soccer players with reduced training but players following a home resistance training programme demonstrated a trivial to small decrease in athletic performance. Given the increased incidence of major knee injuries, such as ruptures to the Anterior Cruciate Ligament (Montalvo et al., 2019) in females in contact sports such as soccer and the evidence for "neuromuscular training" to reduce injury (Hewett et al., 2016), the players' continual engagement with such training throughout the pandemic was a key priority for girls' soccer programmes.

For training to continue during the covid-19 pandemic, virtual physical activity sessions, delivered via platforms such as Zoom or Skype became valid strategies to attenuate the decline in physical outcomes (Shepherd et al., 2021). However, virtual strength and conditioning training delivery, conducted in players' homes reduces the coach's options for ensuring progressive overload, with no access to traditional gym equipment. Thus, continuing to provide an appropriate stimulus to induce internal adaptations and avoid either de-training or overtraining (Impellizzeri et al., 2019) was more challenging. Furthermore, the coach-athlete relationship appears to change when thrust into a virtual environment. On the one hand adaptive and stronger relationships can be developed as coach and athlete discover a new type of relationship. Conversely mal-adaptive relationships can develop as a symptom of distance between coach and athlete (Philippe et al., 2020). COVID-19 restrictions were unprecedented, and little was known about how girls' soccer players would respond to virtual training through the pandemic which provided an important and unique opportunity for learning (Kelly, Erikson & Turnnidge, 2020).

Thus, the aims of this research were to quantify if a home based, virtual strength and conditioning programme could provide equivalent internal physiological stimulus to traditional gym-based session in academy level girls soccer players.

METHODS

Experimental approach to the problem

Using an observational design, we monitored session ratings of perceived exertion (sRPE) in high level girls across 43-weeks of strength and conditioning training. The first 36 weeks were delivered using the Zoom online delivery platform throughout COVID-19 restrictions. The final seven weeks were delivered in a strength and conditioning facility. Parental consent and player verbal assent was gained for all data collection which was part of the clubs regular monitoring procedures, the study was approved by Teesside University School of Health and Life Sciences Research Ethics Committee and all data collected in accordance with the Declaration of Helsinki.

The study was reported following the STROBE reporting guidelines for observational studies (Cuschieri, 2019). Participants were 27 under 14 and under 16 female football players from one English FA Girls Regional Talent Club (age 14.5 ± 0.9 yrs; stature 162 ± 6.0cm; mass 56.8 ± 6.6 kg).

Outcome measures

Differential session ratings of perceived exertion using the CR-100 scale (Borg and Borg, 2002) are valid measures of global, neuromuscular and cardio-respiratory exertion in girls' soccer players (Wright et al., 2020). Ratings of perceived exertion, captured via category ratio scales, have been shown to grow in keeping with classic principles of psychophysics, regardless of gender or age; i.e., in a curvilinear fashion in response to incremental loads and a linear fashion in response to increased repetitions (Buckley & Borg, 2011). Thus, RPE provides an ideal, adaptable monitoring tool for resistance training in the home or the gym. We followed previous methods to collect sRPE using a custom-built app (Wright et al., 2020; Mclaren et al., 2018) to capture global (sRPE-G), breathlessness (sRPE-B), leg muscle (sRPE-L) and upper body (sRPE-U) exertion. RPE collected using validated category ratio scales has been shown to respond as expected to increases in volume (number of repetitions) and load (weight lifted) regardless of gender or age (Buckley and Borg, 2011). Data were collected between 5 and 15 minutes after session completion to aid compliance. Here players were able to see the CR-100 scale and rate how easy or hard the session was in isolation from the influence of other players to reduce the risk of conscious bias (Mclaren et al., 2021).

Training session design

Our strength and conditioning intervention is reported below in-line with the consensus on exercise reporting template (Appendix 1); (Slade et al., 2016). Sessions were group based and supervised by at least two coaches with the lead coach a UKSCA accredited strength and conditioning coach with a minimum of 5 years' experience. Sessions followed a general structure based upon guidelines for youth athletes (Wright & Laas, 2016; Lloyd & Oliver, 2012). Two (70 ± 10 minute) sessions per week were delivered and players were encouraged to attend at least 1 session per week, but attendance was voluntary. Adherence was captured through a custom-built app that enable players to log sRPE and provide individual comments. Time was provided at the end of the session for players to complete this. It is noted that not all players attending on-line training may have been captured due to poor internet connection or a lack of compliance to the session monitoring and not necessarily the session delivery. A total of 27 of the 32 players engaged with on-line session (671 observations; mean attendance 24.5, median 11, inter-quartile range 6.5 to 53 sessions). Some players left the programme at the end of the season and thus 22 of the 27 players attended at least 1 gym-based session (62 observations; mean attendance 2.8, median 2, inter-quartile range 1 to 4). Adherence was compromised in part by periods of enforced isolation due to UK government COVID-19 policies.

All sessions included a warm-up (20 ± 5 minutes) targeting fundamental movement skill competence and followed the R.A.M.P concept (Raise; Activate; Mobilise; Potentiate; Jeffreys, 2019). This was followed by resistance training with the aim of achieving neuromuscular and strength adaptations with a focus on foundational movements; squat, lunge, push, pull, brace and rotate (Lloyd et al., 2015) and specific strengthening targeting the lower limb (hamstrings, quadriceps, calf muscles). Sessions included a mixture of neuromuscular, strength and power-based resistance exercises (6-12 sets of 8-12 reps), typically involving compound exercises and including plyometric progressions and based upon the principles outlined by Wright and Laas (2016). Throughout the virtual delivery progressive overload was attempted by increasing time-under tension, prescribed volume (sets and reps) or by introducing more uni-lateral alternatives. To ensure variation in stimulus the session focus was manipulated every 3-4 weeks between isometric, eccentric or concentric.

Individualising exercises prescription was understandably difficult for virtual sessions, however, where appropriate players were provided with a choice of challenge, for example, split-squat, rear-foot elevated split squat or single-leg squat. Exercises were led by one coach who provided demonstration whilst the second coach observed players technique provided feedback and suggested progression or regressions where appropriate. Where players felt comfortable, they were encouraged to use their camera and microphone to enable coach feedback and recommendations. Where this was not possible players did use the chat function to communicate with coaches.

For the final 7 weeks, sessions in the strength and conditioning facility allowed for the addition of external load through traditional barbells and dumbbells. Here players booked into slots with a maximum of 6 players at one time based on the UK-Government guidelines and institutional risk assessment at the time. Sessions were individualised based upon movement competency (Wright and Laas, 2016) and resistance was self-selected by the player with the goal of completing target repetitions with ~2 repetitions in reserve and without loss of technique.

As part of the FA RTC programme, players and parents were provided additional education sessions, these included education around the strength and conditioning programme, nutrition, women's health, sports psychology and monitoring and evaluation of wellness and the use of ratings of perceived exertion. No adverse events or injuries were reported within strength and conditionings sessions for the duration of this study.

Data processing

A custom-made app was used to collect perceived global (sRPE),leg (sRPE-L), upper body (sRPE-U) and breathlessness (sRPE-B) session exertion data at the end of each training session. Data were then anonymised and downloaded to Microsoft Excel. The data was visually inspected for incorrect entries, correct date format, missing data points and any other errors. The data was filtered into the variables needed for the analysis, loaded into R Studio (R Core Team, 2021) and analysed using the lmer program of the lme4 package (Bates, Maechler, & Dai, 2009).

Mixed linear modelling was chosen to investigate the effect of training modality (independent variable) on internal training load (dependent variable) because this type of modelling supports the analysis of a continuous dependent variable where random effects and repeated measures are present as well as considering any correlated errors. Session RPE, was a dependent variable with training modality (gym or zoom) being the independent variables and the player ID being the random variable. Even though our goal is not to make specific conclusions about differences between any two participants, we are interested in accounting for the influence of the random effects of individuals (Iannaconne et al., 2021) and by doing this, we will be able to draw more precise conclusions about our fixed effects.

Initially an unconditional (baseline) linear mixed model (model A) was constructed (lme4 package) with player ID added as random effect to enable quantification of the within- and between-player variance, but without any predictor of sRPE. Modality (predictor) was then added into the model but further inclusion of covariates, such as age group/team provided no further benefit to the model as verified via both a chi-square distribution (*p*-value of <.001) and comparison of AIC and BIC. The assumption checks of linearity, normality of distribution and the homogeneity of variance of the model were verified visually and whilst Q-Q plots indicated some minor heteroscedasticity it was deemed assumptions were not violated.

An equivalence test using the mean difference of sRPE and differential RPEs between modalities with 90% confidence intervals was calculated (Figure 2), using ±8 arbitrary units (Wright et al. 2020) as our equivalence bounds and was visually inspected (Lakens, Scheel & Isager 2018).

RESULTS

Mean differential sRPE with within- and between-player standard deviation are presented in figure 1 for overall, gym and on-line training.

The mixed linear model with random effects and slopes revealed a statistically significant increase in both sRPE and sRPE-U in gym-based sessions.

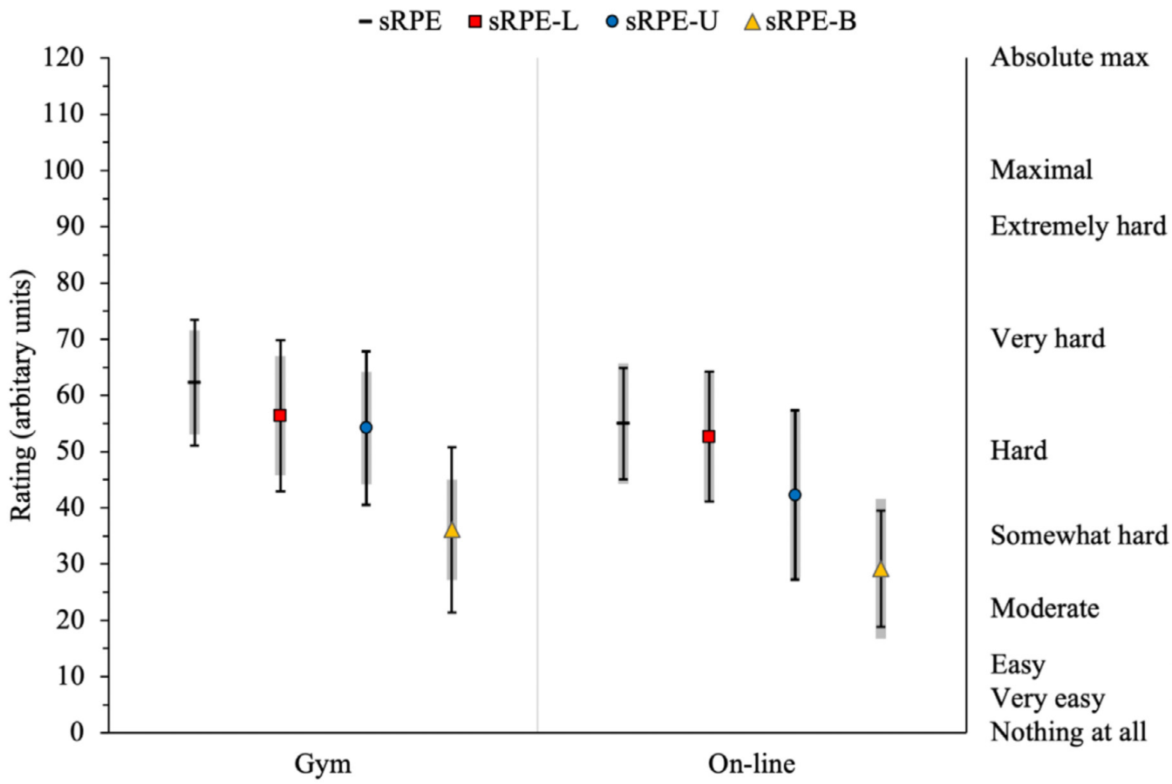

Figure 1. Descriptive statistics for session RPE for gym and on-line training. Variation is expressed as a standard deviation with thick grey error bars representing the within-player variation and thin black error bars representing the between-player variation.

		95% Confidence intervals		
	difference	lower	upper	p-value
sRPE	6.90	3.93	9.87	<0.001
sRPE-L	3.22	0.02	6.46	0.05
sRPE-U	7.58	3.56	11.60	<0.001
sRPE-B	3.06	-0.32	6.45	0.08

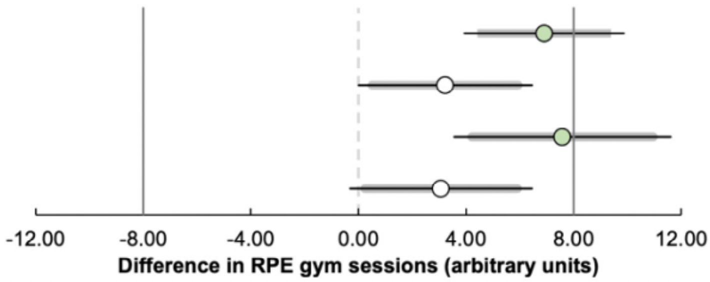

Figure 2. Mean difference between gym based and on-line training sessions with 90% (thick grey line) and 95% (thin black line) confidence intervals plotted against the minimal practically important difference of 8 arbitrary units. Note, positive difference indicates higher RPEs in the gym compared to on-line.

However, these differences were not substantially greater than the minimal practical difference of 8 AU. Visual inspection of equivalence plot showed both sRPE-L and sRPE-U appeared equivalent with the 90% CI falling inside this minimal practical difference (figure 2).

DISCUSSION

We aimed to quantify if home-based virtual strength and conditioning could provide an equivalent load to traditional gym-based session in girls' association football players. The key findings were that whilst global and upper-body RPE were significantly higher in gym-based sessions the magnitude of the difference was not practically meaningful. Global exertion was rated "hard" for on-line sessions and leg-RPE was equivalent across modalities. These data suggest that on-line provides a viable option when in-person strength and conditioning is not feasible. Given the disparity between sexes in resources, including access to facilities, on-line strength and conditioning could provide a feasible option.

On-line sessions were rated as approximately "hard" for both global and leg-RPE, with leg-RPE equivalent to gym sessions. The development of lower body strength and neuromuscular control is important for girls' football players for several reasons. From a performance perspective, the ability of the lower-body to apply force in short periods of time is important for performing soccer specific actions such as sprinting, changing of direction or shooting (Taylor et al., 2020). Increased strength has also been associated with reduced injury risk, for example hamstring, quadriceps or groin strains. Indeed, the majority of time-loss injuries in girls' soccer players in UK talent centres appear to be lower limb soft-tissues injuries that could be preventable through load management and appropriate conditioning (Beech et al., 2022). Furthermore, injuries such as the ACL can often occur in cutting or landing activities, and within the first 50 to 100 ms of ground contact (Krosshaug et al., 2006) and weaker lower limb musculature may predict injury in youth females (Augustsson and Ageberg, 2017). Rapid neuromuscular control is therefore important in reducing such injuries, but rapid isometric force production has been shown to be reduced post peak height velocity. For example, Emmonds et al., (2017) observed substantially lower relative impulse at 100ms on the isometric mid-thigh pull in u14s and u16s players in comparison to u10s and u12s players.

Ratings of perceived exertion have been shown to be valid for resistance training with a large meta-analysis showing strong correlations to resistance training intensity ($r = 0.88$; 95% CI 0.84–0.91) and to EMG ($r = 0.84$; 95% CI 0.56–0.95) (Lea et al., 2022). Furthermore, differential-RPE has shown validity by proof of concept in girls soccer players, differentiating between known differences in training (Wright et al., 2020). We are not aware of data that supports a causal relationship between RPE and neuromuscular adaptations although theoretically, internal load induces positive adaptations (Impellizzeri et al., 2019). It is somewhat unknown if exposure to strength and conditioning sessions perceived to be "hard" provides an appropriate stimulus to enhance neuromuscular performance. Mclaren et al., (2018) observed that breathlessness-RPE was very likely higher in rugby players who improved yo-yo test performance, but all other comparisons were unclear. However, RPE follows the classic psychophysical response curve to incremental resistance training loading in lower and upper body and can be used to set theoretical estimate of percentage one repetition max (Buckley and Borg). Wright, Jones and Edwards (2022) showed practically important improvements in counter-movement jump after a 6-week, low frequency strength training intervention, in the same cohort with leg-RPE again perceived to be "hard". Others have shown resistance training between "hard" and "very hard" on Borg's CR-10 RPE scale to improve psychological outcomes including a decrease in anxiety (Faro et al., 2019). On balance, we suggest the exertion reported here for both on-line and gym-based sessions appears adequate to stimulate positive adaptations, both physiological and psychological, given adequate consistency of training.

Given the context of this research, collected throughout periods of COVID-19 lock down in the UK, it is also particularly important to consider other benefits beyond those measurable through perceived exertion or physical performance measures. Social isolation through lockdown periods negatively affects children and adolescents' mental health (Loades et al., 2020). This could have been particularly challenging for girls' team sport athletes given the importance of social interaction, linked to increase levels of Oxytocin, a neuropeptide which is higher at rest in females than males (Marazziti et al., 2019) and associated with social bonding and teamwork. Resistance training itself has been shown to enhance children's perceptions of "The Self" with positive effects on self-efficacy, physical and global self-worth (Collins et al., 2019) but the opportunity to interact with teammates should not be overlooked. Practitioners report how these sessions provided an opportunity for the girls to interact socially, with players and coaches usually staying on the call for an extend period after the session to talk. Indeed, a challenge of moving into a virtual environment was the potential for the coach-athlete relationship to change, positively and negatively (Philippe et al., 2020). This is potentially reflected in adherence with on-line sessions which was poor in some players and very good in others (IQR 6.5 to 53 sessions). Some were reluctant to share camera or microphones; others attended sessions but did not log RPE scores consistently. During independent post training focus groups, as part of service evaluation, players stated lack of internet, parental support, motivation to train when football was cancelled and access to a laptop / tablet as reasons for non-compliance. Some players also referenced negative pre-conceived ideas about "on-line" training. However, some players engaged fully, and coaches had a unique insight into life outside of sport, providing opportunities for coaches and players to interact at a very human level.

This study is not without its limitations, firstly this represents an applied observation, rather than experimental study which may limit the level of evidence in support of our conclusion of the data. Furthermore, our findings may be limited both to the population, girls' football players, and the context throughout a period typified by social restrictions including lockdowns. We were also unable to quantify external load for this study, given the challenges of delivering virtual sessions it was difficult to verify even simple measures of sets and repetitions completed on an individual level. Adherence to training and monitoring was also a challenge here, both with on-line sessions and gym-based training, partly because of limited numbers for social distances and numerous players required to isolate for ~10 days due to COVID-19 infections. This led to a reduced number of observations, particularly for gym-sessions. That said, our estimates were similar to those presented previously in this cohort for gym-based resistance training across 558 observations (Wright et al., 2020). Furthermore, mixed-linear models are robust and capable of accounting for uneven variance (McElreath, 2018).

CONCLUSIONS

On-line strength and conditioning sessions are a viable alternative to gym-based session to provide internal lower-limb neuromuscular stimulus in girls' association football players. This may have practical application beyond the COVID-19 pandemic as this modality may enable practitioners to provide beneficial support to girls without access to facilities or specialist equipment. However, there may be barriers to players adhering to on-line sessions and adherence should be monitored closely.

CONFLICTS OF INTEREST

There are no conflicting relationships or activities.

FUNDING

This study received no specific funding in order to be completed.

ETHICAL APPROVAL

Ethics for this study were approved in line with

University's ethics procedure.

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APPENDIX

Appendix 1. Consensus on exercise reporting template (CERT)

	Checklist item	Primary paper	
1	Detailed description of the type of exercise equipment (e.g. weights, exercise equipment such as machines, treadmill, bicycle ergometer etc)	Y	
2	Detailed description of the qualifications, teaching/supervising expertise, and/or training undertaken by the exercise instructor	Y	
3	Describe whether exercises are performed individually or in a group	Y	
4	Describe whether exercises are supervised or unsupervised and how they are delivered	Y	
5	Detailed description of how adherence to exercise is measured and reported	Y	
6	Detailed description of motivation strategies	N/A	Beyond the scope of this manuscript.
7a	Detailed description of the decision rule(s) for determining exercise progression	Y	See Wright and Laas (2016)
7b	Detailed description of how the exercise program was progressed	Y	See Wright and Laas (2016)
8	Detailed description of each exercise to enable replication (e.g. photographs, illustrations , video etc)	N/A	Beyond the scope of this manuscript.
9	Detailed description of any home program component (e.g. other exercises, stretching etc)	N/A	
10	Describe whether there are any non-exercise components (e.g. education, cognitive behavioural therapy, massage etc)	Y	
11	Describe the type and number of adverse events that occurred during exercise	Y	
12	Describe the setting in which the exercises are performed	Y	
13	Detailed description of the exercise intervention including, but not limited to, number of exercise repetitions/sets/sessions, session duration, intervention/program duration etc	Y	
14a	Describe whether the exercises are generic (one size fits all) or tailored whether tailored to the individual	Y	See Wright and Laas (2016)
14b	Detailed description of how exercises are tailored to the individual	Y	
15	Describe the decision rule for determining the starting level at which people commence an exercise program (such as beginner, intermediate, advanced etc)	Y	See Wright and Laas (2016)
16a	Describe how adherence or fidelity to the exercise intervention is assessed/measured	Y	
16b	Describe the extent to which the intervention was delivered as planned	Y	