Phases of the Traditional 505 Test: Between Session and Direction Reliability

Type: Original Investigation

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Abstract

Change of direction (COD) testing has commonly reported a single total time to quantify performance despite that tests are made up of a number of different phases. No investigation into these phases has been completed, therefore the aim of this study was to examine the reliability between sessions and directions of the different phases of a 505 test. Twenty-one male youth athletes performed the 505 test in both directions on three occasions. Differences between directions and sessions were determined via a T-test and Two-way ANOVA respectively and a significance threshold was set at $P \leq 0.05$. All strategy variables show acceptable relative and absolute reliability in both directions between sessions (ICC = 0.73-0.94; CV = 2.3-6.3%) apart from ground contact time (GCT) (ICC = 0.57-0.68, CV = 14.8–22.4%). Significant differences were identified between session one and three for entry time. Significant differences between directions for exit time on day two and for full approach, entry and GCT on day three. The non-dominant turning direction showed lower relative and absolute reliability between session for entry time (ICC = 0.73 vs 0.89; CV = 6.3% vs 3.7%) and GCT (ICC = 0.57 vs 0.68; CV = 14.8% vs 22.4%). Results indicate the phases of a 505 COD test have high relative and absolute reliability between sessions, although turning directions should be considered independently.

Key Words: Agility; Deceleration; Velocity; Braking; Change of Direction

Les phases du test traditionnel 505 : Fiabilité entre les sessions et les directions

Résumé

Les tests de changement de direction rapportent généralement un seul temps total pour quantifier la performance bien que les tests soient composés de plusieurs phases distinctes. Aucune investigation sur ces phases n'a été réalisée à ce jour, donc le but de cette étude était d'examiner la fiabilité entre les sessions et les directions des différentes phases d'un test 505. Vingt et un jeunes athlètes masculins ont effectué le test 505 dans les deux sens à trois jours d’intervalle. Les différences entre les directions et les séances ont été déterminées respectivement par un test T et une ANOVA bidirectionnelle respectivement avec un seuil de significativité fixé à $P \leq 0,05$. Toutes les variables de stratégie montrent une fiabilité relative et absolue acceptable dans les deux sens entre les sessions (ICC = 0,73 - 0,94 ; CV = 2,3 - 6,3%) en dehors du temps de contact avec le sol (ICC = 0,57 - 0,68, CV = 14,8 - 22,4%). Des différences significatives ont été identifiées entre la session une et trois pour le temps d'entrée. Différences significatives entre les directions pour le temps de sortie le deuxième jour et pour l'approche complète, l'entrée et le temps de contact avec le sol, le troisième jour. La direction de rotation non dominante a montré une fiabilité relative et absolue inférieure entre session pour le temps d'entrée (ICC = 0,73 vs 0,89 ; CV = 6,3% vs 3,7%) et le temps de contact avec le sol (ICC = 0,57 vs 0,68 ; CV = 14,8% vs 22,4%). Les résultats indiquent que les phases d'un test 505 COD ont une fiabilité relative et absolue élevée entre les sessions, bien que les directions de virage doivent être considérées indépendamment.

Mots clés: Agilité; Ralentissement; Rapidité; Freinage; Changement de direction

INTRODUCTION

The importance of change of direction (COD) speed for sports performance is well established (Little & Williams, 2005; Sheppard & Young, 2006). A variety of tests have been developed in an attempt to measure this physical quality (Stewart, Turner, & Miller, 2014) and results are used to inform the training process. One common protocol is the 505 test (Draper & Lancaster, 1985), which displays excellent reliability (CV = 1.9-2.4%) (Barber, Thomas, Jones, McMahon, & Comfort, 2016; Stewart et al., 2014). The 505 test involves a number of different phases; a 15m approach which includes a maximal acceleration and a deceleration to a complete stop (Jones, Herrington, & Graham-Smith, 2016), a turn of 180° and a 5m re-acceleration into the new direction. Thus, the use of a single total time measure to quantify an athlete's performance is likely insufficient (Dos'Santos, Thomas, Jones, & Comfort, 2018; Myer et al., 2011; Nimphius, Callaghan, Spiteri, & Lockie, 2016; Sayers, 2015).

Recently the 'COD Deficit' has been proposed to provide a more accurate measure of COD ability by controlling for the influence of an athlete's linear speed (Nimphius et al., 2016). COD deficit has since also been used to more accurately identify asymmetry in turning directions (Dos'Santos et al., 2018; Myer et al., 2011; Sayers, 2015). However, this metric is still a composite of multi-directional re-acceleration and deceleration. Assessing deceleration (entry) or acceleration (exit) abilities independently can help improve our understanding of how athletes change direction, allowing coaches to more clearly examine an athlete's task completion strategy and design individualised training programmes (Nimphius, Callaghan, Bezodis, & Lockie, 2018). The completion of the 505 test may be sectioned into an initial 10m acceleration, a 5m entry period (deceleration) and a 5m exit period (re-acceleration), which allows for the addition of entry and exit time (505 time) and the full 15m approach time. However, the reliability of these phases remains unknown and requires further investigation.

Learning effects may be present during COD testing, affecting test reliability (Barber et al., 2016; Munro & Herrington, 2011). Munro and Herrington (2011), reported significant improvements in T-test COD performance within the first test session, highlighting the need for appropriate familiarisation to the test before reliability data can be collected. In addition, despite excellent levels of between session reliability (ICC = 0.95, Smallest detectable difference = 0.10 s, 3.97%) Barber at al., (2016) reported significantly faster dominant limb 505 performance on testing days three and four vs day one. Due to the common reporting of 505 test performance as a total time measure, it is also unclear how familiarisation effects the overall strategy used to complete the task. It may be that the changes in performance reported over multiple testing sessions (Barber et al., 2016) may be mainly due to changes in one particular phase of the test. Investigating this will help guide practitioners and researchers in applying the most effective test familiarisation strategies. Therefore, a greater understanding of between session learning effects and reliability is needed for both turning directions and the different phases which contribute to the total COD performance.

Cumulatively, there is a paucity of literature to examine the between session and turning direction reliability of the different phases which make up an athlete's COD task performance. Therefore, the primary aim of this study was to examine the between session reliability in the initial approach, entry to the turn, full approach, ground contact time (GCT) and exit from the turn during the 505 test. The secondary aim of this study was to investigate how the reliability of these phases change between the dominant and non-dominant turning direction of the 505 test. It is hypothesised that total time measures would show higher levels of reliability vs the different phases which contribute to the overall performance and the non-dominant turning direction will be less reliable throughout. It is also hypothesised that there will be no learning effects throughout the study in any phase of the COD test.

METHODS

Subjects

Twenty-one competitive male youth rugby athletes volunteered to take part (age 16.0 ± 0.5 y, body mass 84.2 ± 13.5 kg, stature 176.4 ± 6.0 cm). All subjects had been engaged in a formalised strength and conditioning for a minimum of 12 months prior to the testing period and were required to be free from injury and familiar with the 505 test. The study was approved by the university's research ethics committee in accordance with the Declaration of Helsinki. All subjects and their parents/guardians were informed of the risks and procedures and written participant assent and parental consent were obtained prior to testing.

Study Design

A repeated measures study design was used to examine the between session reliability of task strategy metrics on the dominant and non-dominant turning directions during the 505 COD test (Draper & Lancaster, 1985). Subjects were required to attend testing at the same day/time once a week on four separate occasions during the competitive season. The first session was used for familiarisation where subjects completed 3 test practice attempts in both turning directions. The final three sessions were used to collect 505 performance data and took place prior to their normal training session and approximately 48 hours after a competitive match. The protocol was completed on an indoor 3G training surface and subjects were instructed to wear the same moulded boots each week, as they would for their normal training. Each session began with a standardised warm up including 5-min of various pulse-raising activities, including linear and multidirectional movements which mimicked the 505 test, and 5-min of dynamic muscle activation exercises such as body weight lunges, squats and dynamic stretches. Subjects completed 6 trials (3 in each direction), with a minimum rest period of at least 2 minutes between trials. All timing variables were reported to the nearest 0.01 seconds.

Procedures

505 Test

The 505 test was administered in accordance with previous studies (Draper & Lancaster, 1985). Time was recorded utilising single beam infrared photocells (Witty, Microgate, Italy) and a beam-based ground contact system (OptoJump, Microgate, Italy) which are automatically time synchronised within the same software package (Opto Jump Next, V1.12.15, Italy). Timing gates were placed at 0 and 10m, and the beam-based ground contact system was positioned on the ground with the 15m line intersecting the Opto Jump bars, avoiding interference from the artificial grass by raising the Opto Jump bars 8mm (Figure 1). This set up ensured that both the GCT of the plant step and the time at which the plant step occurs at the 15m point were both captured.

Subjects began each sprint 50 cm behind the 0 m line in a two-point staggered stance (Altman et al., 2015; Haugen and Buchheit, 2016). Instructions were to get to the turn line (contacting either their left or right foot on the 15m line dependant on the turn's direction) and then to re-accelerate 5m as fast as possible. Each session consisted of six trials (three turning left and three turning right) with a consistent turning direction being maintained for three trials in a row but initial direction being randomly allocated each week. The dominant turning direction was considered by the turning direction which resulted in the fastest trial. This is due to limb dominance being task dependant (Bishop, Turner, Jarvis, Chavda, & Read, 2017; Dos'Santos, Bishop, Thomas, Comfort, & Jones, 2019) and both limbs contributing to performance in the test (Dos'Santos, Thomas, Jones, & Comfort, 2017). The fastest 505 trial recorded in each session was utilised in analysis and all phases investigated came from the same trial (Barber et al., 2016; Draper & Lancaster, 1985; Nimphius et al., 2016). In order for a trial to be considered successful, the subject had to reach the 15m line with their plant step and change direction in one single plant step ground contact, if this single contact plant step did not occur the subject was asked to repeat the test. This was to ensure that the end of the deceleration phase could be repeatedly identified during a single foot contact instead of across multiple shorter foot adjustments. The phases investigated throughout the test were calculated as follows:

Initial approach time: The time from 0m to 10m

Entry time: The time from the 10m gate to 50% of ground contact during the plant step. 50% of ground contact was used to ensure the athlete fully decelerated before time was considered to contribute to the exit speed (Hanson, Padua, Troy Blackburn, Prentice, & Hirth, 2008).

Full approach time: The time from the 0m gate to 50% of GCT of the plant step

Time to Plant: The time from 0m to ground contact with the plant step during the turn.

Exit time: The time from 50% of the plant step to the point the athlete returned through the 10m timing gate.

505 Time: The total time measured from the moment of passing through the 10m gate to the athletes return through the 10m gate after performing the 180° COD on the 15m line.

Total time: The time from 0m until the athlete had returned through the 10m gate after the COD.

505 Entry Contribution: The percentage of 505 time which is taken up by the entry time.

*** Insert Figure 1 here ***

Statistical Analysis

Statistical analyses were performed using SPSS (v22.0). The distribution of raw data sets were checked for homogeneity and skewness using the Kolmogorov-Smirnov test. Descriptive statistics including means and standard deviation were calculated for each measure. Between session reliability was calculated for both the dominant and the non-dominant turning direction utilising the best trial in each direction in each session (Barber et al., 2016). All phases of the test used for analysis were taken from these same trials with the dominant direction being identified via fastest 505 time. All phases were treated as separate dependant variables and were analysed via the same reliability calculation. Intraclass correlation coefficient (ICC) via a two-way mixed effects model (3,1), Typical Error (TE) and Coefficient of Variation (CV) were calculated with 90% Confidence Intervals (CI). The CV was performed to allow for comparison of error between the variables (CV) given their different durations and is considered a measure of absolute reliability. ICC was utilized to identify the rank order repeatability and to examine the relative reliability of each variable. The TE is reported in order to represent the within subject standard deviation. All reliability measures were considered in relation to the guidelines outlined by Koo and Li (Koo & Li, 2016). Paired samples t-tests were performed for all variables to examine mean differences in strategy between dominant and non-dominant turning directions on all testing days. A one-way repeated measures ANOVA with a post hoc Bonferroni was also performed in order to investigate if there was any systematic bias or strategy alteration between the three test sessions. The Alpha level was set to $P \leq 0.05$.

RESULTS

Descriptive statistics and reliability data are displayed in Table 1. Results showed that initial approach, time to plant, full approach, entry, 505, exit time and total time all demonstrate moderate to excellent levels of relative reliability in all methods of analysis (ICC = 0.73 – 0.94) and acceptable absolute reliability (CV = 2.3% - 6.3%) (Table 2). GCT is reported to have moderate relative reliability during dominant and non-dominant turning directions (ICC = 0.68 and 0.57 respectively) but shows lower levels of absolute reliability with CV's between 14.8% and 22.4%. Post-hoc analysis of the repeated measures ANOVA showed a significant difference (P = 0.012) was present between session one and session three for dominant direction entry time indicating systematic bias, but no differences were observed between testing sessions for any other variable.

Paired samples t-test results showed significant differences between turning directions when comparing 505 time on Day 1 (P = 0.027), Day 2 (P = 0.013) and Day 3 (P = 0.001) and total time on Day 1 (P = 0.046), Day 2 (P = 0.001) and Day 3 (P < 0.001). Significant differences in exit time were reported between turning directions on day two (P = 0.031) and between directions for full approach (P = 0.025), entry (P = 0.004) and GCT (P = 0.028) on day three.

*** Insert Table 1 and Table 2 here ***

DISCUSSION

The aim of the current study was to investigate the between session reliability of the different phases of a 505 test on both dominant and non-dominant turning directions. Results indicate that initial approach, full approach, time to plant, entry, exit and 505 time have moderate to excellent levels of absolute and relative reliability. However, GCT shows a substantially higher CV than other variables and moderate relative reliability for dominant (CV = 14.8%, ICC = 0.68) and non-dominant (CV = 22.4%, ICC = 0.57) directions so should be interpreted with caution. These data indicate a range of parameters that describe an athlete's COD task completion strategy display suitable between session reliability and thus can be used to monitor temporal changes in athlete performance.

The primary finding of the current study showed that when the full approach is divided into distinct phases of initial approach and entry variables, variation of these measures increases resulting in a decrease in ICC's and an increase in CV (Table 2). The same is seen when 505 time is split into an entry and an exit time (Table 2). Therefore, it can be assumed that metrics which divide a task into subcomponents results in increased variation and lower levels of reliability. Global parameters with more constituent parts remain stable; however, more variability is found in the finite components of the task without an impact on the global outcome, supporting the concept of redundancy outlined by Bernstein (1967). It is also apparent that exit time shows more variation than entry time, which may be due to the preceding influence of the approach speed, either advantaging or disadvantaging effective exit speed (Spiteri, Cochrane, Hart, Haff, & Nimphius, 2013; Spiteri, Newton, & Nimphius, 2015). Therefore, it may be concluded that variables that occur later in a sequence of events will be less reliable than those that occur earlier because of the previous movements, thus requiring larger magnitudes of change to be confident that observed differences are real.

Another important finding is that a significant decrease in dominant turning direction entry time was observed between sessions one and three. This indicates that despite 505 performance remaining stable across test sessions and entry time being reported as reliable (CV = 3.7, 6.3% for dominant and non-dominant directions respectively), an alteration in dominant direction turning strategy is present over time via performance improvements during the braking phase. However, this interpretation is from the groups mean data and may not represent the strategy alteration of all subjects. While the current results do not show the significant improvement in 505 time over multiple testing sessions identified by Barber et al., (2016) these 505 performance improvements previously shown may be mainly caused by changes in entry time. This indicates that the entry phase may require further familiarisation prior to testing and specific instructions may be provided to help athletes explore how fast they can enter a COD task whilst trying to optimise performance, but this requires further research.

Significant differences were observed between turning directions for 505 time and total time on all testing days, when comparing exit time on day two, and when comparing full approach, entry and GCT on day three. These results also indicate that small variations in strategy are likely between sessions; however, the acceptable test re-test reliability confirms that we can confidently use these metrics to measure changes in performance over time. The significant difference found in entry and approach time between directions on day three may also be the main contributors to the significant reduction in entry time between the first and final session, potentially representing a performance learning effect on the dominant turning direction. This supports the conclusions from Dos'Santos et al., (2018) who reported enhanced asymmetry detection by using COD deficit (controlling for linear speed and increasing the influence of the entry phase) rather than total 505 time. Despite its lower level of reliability, results suggest that GCT may be a key variable between turning directions as on day 3 a significant difference was found for GCT and full approach, but not for time to contact. This suggests that it is the influence of GCT which results in the faster full approach time on the dominant turning direction, potentially due to more penultimate step force absorption resulting in a shorter plant step GCT (DoS'Santos, Thomas, Jones, & Comfort, 2017). This provides further insight to the emergence of turning strategy asymmetries and should be further investigated.

Directional differences can also be observed in reliability data as the non-dominant direction shows a reduction in absolute reliability (average CV reduction of 1.7%) and relative reliability (average ICC reduction of 0.04) across variables with entry and exit time being the most affected. This may indicate more within subject variability and a greater propensity for rank order changes during these phases of the test in the non-dominant turning direction. Total time is the least affected which may be due to total time being the only variable which considers all aspects of the test. This indicates that while athletes are still able to complete the overall task in their non-dominant turning direction with excellent reliability, the variables representing strategy show a trend for greater variability due to the changes in how the task is completed (Bernstein, 1967). These results support the need for independent reporting of dominant and non-dominant turning directions and indicate that worthwhile changes in performance should be calculated specific to the turning direction and phase of the test.

The lower levels of reliability shown for GCT in the current study is likely due to this variable being dependent on a range of factors such as entry speed, the distribution of braking force between the penultimate and plant step, and the kinematics during the plant step (DoS'Santos et al., 2017). However, it is important to remember that the first and second half of GCT is used to contribute to entry and exit time (Hanson et al., 2008), which both show higher levels of reliability (entry CV = 3.7-6.3%, exit CV = 4.4%-5.9% for dominant and non-dominant directions respectively). Furthermore, the lower reliability displayed by GCT may not come as a surprise due to a low absolute mean value with a high standard deviation, increasing the CV.

When interpreting the results of the current study, care should be taken when using ICC's to interpret reliability as it refers to the rank repeatability of the results and does not clearly infer the magnitude of variability within the variable (Rankin & Stokes, 1998). The CV on the other hand is known as absolute reliability due to it representing the average variation in test scores for the individuals within the group. For example, GCT has a maximum CV of 26% on the non-dominant turning direction, indicating that a change in GCT of 0.10 seconds would be required in order to see meaningful changes in GCT from training. The magnitude of this change should be considered when determining if the GCT should be isolated during testing.

The results of this study allow coaches and researchers to more confidently isolate different phases of COD tests to gain greater insight into how the task is completed. Future research should utilise this information during testing in order to further our understanding of both performance and potential injury risk. The CV values for the different phases should also be utilised to help infer real performance changes during interventions. Finally, it is recommended that coaches pay particular attention to the familiarisation of the entry phase as it is possible that performance changes may occur in short spaces of time.

In conclusion, the strategy athletes utilise to complete a 505 COD test has both high relative and absolute reliability, but the greater variability is present if a 'task' is further broken down into its constituent parts or if a component which occurs later in a sequence of events is considered. Furthermore, turning directions should be considered independently as differences in reliability and task completion strategy are likely to exist. For the purposes of monitoring longitudinally, it is recommended to provide adequate familiarisation and for coaches to encourage athletes to explore their optimal entry speed.

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Table 1: Mean (SD) for each phase and overall performance of the 505 test

	Between Session Trials					
	Dominant			Non-Dominant		
	Week 1	Week 2	Week 3	Week 1	Week 2	Week 3
Initial Approach (s)	1.86 (0.16)	1.88 (0.18)	1.88 (0.17)	1.87 (0.17)	1.88 (0.18)	1.90 (0.21)
Full Approach (s)	3.03 (0.26)	3.03 (0.28)	3.01 (0.24)*	3.05 (0.26)	3.02 (0.29)	3.07 (0.30)
Time to Plant (s)	2.83 (0.24)	2.84 (0.27)	2.81 (0.22)	2.85 (0.24)	2.83 (0.30)	2.85 (0.29)
Total (s)	4.32 (0.37)*	4.33 (0.39)*	4.30 (0.35)*	4.40 (0.38)	4.38 (0.4)	4.39 (0.41)
Entry (s)	1.17 (0.12)§	1.15 (0.12)	1.12 (0.11)*	1.19 (0.14)	1.15 (0.14)	1.16 (0.12)
Exit (s)	1.29 (0.13)	1.30 (0.15)*	1.29 (0.15)	1.34 (0.19)	1.35 (0.15)	1.32 (0.14)
505 (s)	2.46 (0.22)*	2.45 (0.22)*	2.42 (0.22)*	2.53 (0.26)	2.50 (0.24)	2.48 (0.21)
GCT (s)	0.44 (0.11)	0.42 (0.09)	0.41 (0.10)*	0.48 (0.15)	0.44 (0.14)	0.47 (0.12)

* sig difference ($P<0.05$) between dominant and non-dominant turning direction within the same testing day. § sig difference ($P<0.05$) between week 1 and week 3 on the same turning direction

Table 2: Intra-class Correlation Coefficients (ICC's) Typical Error (TE), and Coefficient of Variation (CV) with a 90% confidence interval for all measured variables on the dominant and non-dominant side between sessions.

		Between Session Reliability	
		Dominant	Non-Dominant
Initial Approach	**ICC**	**0.88** (0.78 - 0.94)	**0.88** (0.79 - 0.94)
	TE (s)	**0.36** (0.30 - 0.47)	**0.36** (0.30 - 0.46)
	CV (%)	**3.30** (2.70 - 4.20)	**3.50** (2.90 - 4.50)
Time to Plant	**ICC**	**0.91** (0.83 - 0.95)	**0.89** (0.80 - 0.95)
	TE (s)	**0.32** (0.27 - 0.41)	**0.35** (0.29 - 0.44)
	CV (%)	**2.70** (2.30 - 3.50)	**3.30** (2.80 - 4.30)
Full Approach	**ICC**	**0.93** (0.87 - 0.97)	**0.92** (0.84 - 0.96)
	TE (s)	**0.28** (0.23 - 0.36)	**0.31** (0.25 - 0.39)
	CV (%)	**2.40** (2.00 - 3.10)	**2.90** (2.40 - 3.70)
Entry	**ICC**	**0.89** (0.79 - 0.94)	**0.73** (0.54 - 0.86)
	TE (s)	**0.36** (0.30 - 0.46)	**0.54** (0.45 - 0.70)
	CV (%)	**3.70** (3.00 - 4.80)	**6.30** (5.20 - 8.20)
Exit	**ICC**	**0.85** (0.72 - 0.92)	**0.77** (0.61 - 0.88)
	TE (s)	**0.41** (0.34 - 0.53)	**0.50** (0.41 - 0.64)
	CV (%)	**4.40** (3.60 - 5.60)	**5.90** (4.90 - 7.70)
505	**ICC**	**0.91** (0.83 - 0.95)	**0.89** (0.80 - 0.94)
	TE (s)	**0.32** (0.26 - 0.41)	**0.35** (0.29 - 0.45)
	CV (%)	**2.80** (2.30 - 3.60)	**3.30** (2.70 - 4.20)
Total Time	**ICC**	**0.93** (0.87 - 0.97)	**0.94** (0.88 - 0.97)
	TE (s)	**0.28** (0.23 - 0.36)	**0.27** (0.22 - 0.34)
	CV (%)	**2.30** (1.90 – 3.00)	**2.40** (2.00 - 3.10)
GCT	**ICC**	**0.68** (0.47 - 0.83)	**0.57** (0.33 - 0.76)
	TE (s)	**0.59** (0.49 - 0.75)	**0.67** (0.55 - 0.86)
	CV (%)	**14.80** (12.20 - 19.50)	**22.40** (18.20 - 29.60)

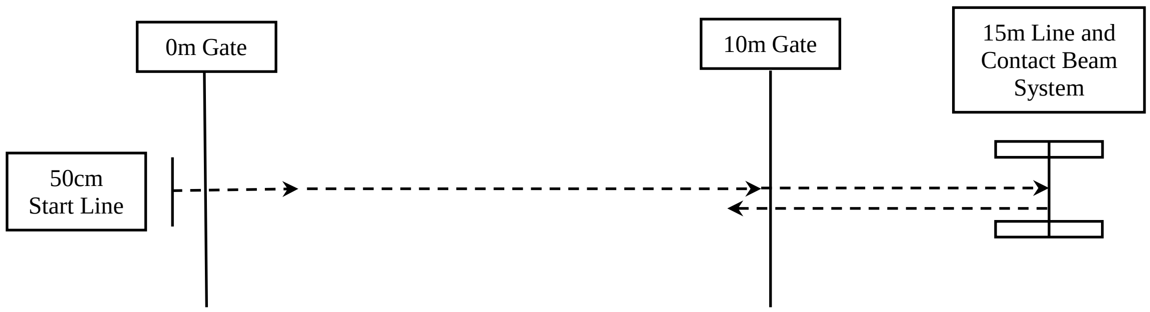

Figure 1: A visual representation of the 505 COD test