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RESEARCH REPORT

Sincerity of effort versus feigned movement control of the cervical spine in patients with whiplash-associated disorders and asymptomatic persons: a case–control study

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Abstract

Study design: Cross-sectional design. *Objectives*: To investigate whether the Fly Test can be used to differentiate patients with whiplash-associated disorders (WAD) from asymptomatic persons who deliberately feign symptoms and from WAD patients exaggerating symptoms. *Background*: The lack of valid clinical tests makes it difficult to detect a justifiable cause for compensation claims in traumatic neck-pain disorders. *Methods*: The Fly Test recorded the accuracy of neck movements in patients with WAD ($n = 34$) and asymptomatic persons ($n = 31$). The participants followed a moving ''Fly'' on a computer screen with a cursor from sensors mounted on the head. Two conditions were tested, sincere versus feigned efforts. In the former, the participants moved their neck as accurately as possible. In the latter, a short text was presented describing a fictitious accident (asymptomatic group) or imagining more intense pain/suffering (WAD group), and the test was performed as affected by these more serious conditions. Amplitude accuracy (AA), time on target (ToT) and jerk index (JI) were compared across patterns, conditions and groups. *Results*: The sincere effort in the WAD group was significant compared to the feigned effort of the asymptomatic group ($p < 0.001$). For AA, correct categorization of 81.5% of the performances was made, where a mean score above 5.5 mm differentiated feigned versus sincere efforts in asymptomatic and WAD groups (sensitivity 79.4%, specificity 67.7%). For ToT, score above 11% indicated correctly categorized WAD patients (sensitivity 82.4%, specificity 64.5%). *Conclusion*: The Fly Test can provide clinicians a clue when patients with mild to moderate pain/disability are feigning or exaggerating symptoms.

Keywords

Cervical spine, classification, fraud, movement control, whiplash claims

History

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Introduction

Insurance fraud related to whiplash injuries is a widespread problem worldwide (Coalition Against Insurance Fraud, 2014; Insurance Bureau of Canada, 2014; Insurance Fraud Bureau UK, 2014). It has been stated that whiplash injury is easy to fake and difficult to disprove, leading to a high proportion of fraudulent claims (Association of British Insurers, 2012). According to the Association of British Insurers (ABI), fraudulent claims are thought to be a major contributor toward the increased premiums of 40% for average auto insurance in the UK from 2010 to 2011. ABI believes that about 133 000 false claims were made in the UK over the course of 2010. Three-quarters of personal injury claims in UK are for whiplash, where insurers pay out over £2.2 billion a year in claims for whiplash (Association of British Insurers, 2008, 2012, 2013), adding an extra £90 to the average annual auto insurance premium (Association of British Insurers, 2013). The increase in whiplash claims in the UK by a third over the past 3 years occurs against a 20% fall in the reported number of traffic accidents to the police between 2006 and 2011 (Association of British Insurers, 2012, 2013). This underpins the proposition that some who have been exposed to motor vehicle collision (MVC) may deliberately be faking symptoms or insincerely be attributing some of their complaints to such an event (Ferrari and Russel, 1999). Fraudulent whiplash claims based on staged accidents are estimated to cost the UK insurance industry between £75 and 110 million every year, representing 5% of all whiplash claims (Association of British Insurers, 2008).

Patients with whiplash-associated disorders (WAD) who are still symptomatic despite numerous physical treatments and medical care take the natural course of action of seeking compensation for their chronic symptoms. Not surprisingly, patients with chronic WAD have a poor reputation due to these compensation claims, especially as no demonstrable patho-anatomical signs can usually be detected to justify them (Kristjansson, 2004). The inability of the healthcare system to detect a justifiable cause for the complaints to make a compensation claim is therefore very unsatisfactory for real patients, the healthcare system and the third-party payers (Kristjansson, 2004). The nature of the relationship between compensation-related factors and health is unclear (Spearing and Connelly, 2011), and the association with persistent symptoms after whiplash are often interpreted as evidence that compensation affects health (Spearing

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and Connelly, 2011). Although fraud may exist, clinical research suggests that up to 50% of patients will never fully recover from a whiplash injury following an MVC (Carroll et al, 2008), making it difficult to readily refute that a real injury has occurred.

Despite several attempts to differentiate feigned performances in WAD from genuine ones on diverse physical tests (Baydal-Bertomeu et al, 2011; Dvir, Prushansky, and Peretz, 2001; Dvir et al, 2004; Prushansky, Pevzner, and Dvir, 2006; Vernon, Tran, Soave, and Moreton, 2010) no such test has yet been optimized. The Fly Test is a new clinical method that assesses the deficits of movement control in the cervical spine in real time and has been found to be both reliable and valid (Kristjansson and Oddsdottir, 2010). The Fly Test has been carried out on patients with traumatic and non-traumatic neck pain, as well as on asymptomatic persons (Kristjansson and Oddsdottir, 2010), where its capability to discriminate significantly between the three subject groups was revealed. The Fly Test addresses regulation of movement through feedback and reflex mechanisms (i.e. the detection and correction of errors, while performing active movements) (Gandevia and Burke, 1992; Kristjansson and Oddsdottir, 2010; Prochazka, 1996). Several studies have revealed impaired cervical kinesthesia in patients with WAD (Feipel, Salvia, Klein, and Rooze, 2006; Kristjansson, Dall'Alba, and Jull, 2003; Kristjansson, Hardardottir, Asmundardottir, and Guðmundsson, 2004; Sterling et al, 2003; Treleaven, Jull, and Sterling, 2003) and suggested that this impairment may be one of the factors related to the chronicity of whiplash symptoms (Kristjansson and Treleaven, 2009). The present study was undertaken to further the development of the Fly Test (Kristjansson and Oddsdottir, 2010) by introducing jerk as the third outcome measure. The Fly Test's three outcome measures: (1) amplitude accuracy (AA); (2) time on target (ToT) and (3) jerk index (JI) were used to differentiate sincere versus feigned performances among patients with chronic WAD and asymptomatic persons. A case–control study was conducted.

The aims of the study were twofold: primarily to determine if the Fly Test is useful in differentiating real patients with WAD from asymptomatic persons acting as if they were injured; and secondarily, from those patients with WAD who exaggerate their symptoms and thereafter to ascertain the capability of the Fly Test to discriminate between the sincere performances of the two groups of participants, chronic WAD and asymptomatic persons. The hypothesis was that one or all three outcome measures of the Fly Test would be capable of discriminating real patients with WAD from those who are not.

Methods

Participants

The demographics of the 65 participants recruited for the study are shown in Table 1. They were divided into asymptomatic ($n = 31$) and WAD ($n = 34$) groups. Samples of convenience were used. The asymptomatic participants were recruited from staff in government agencies, diverse local businesses and students from public schools. A history of musculoskeletal pain or injury in the neck excluded participation in the asymptomatic group. Patients with persistent WAD grade II were recruited through contacts with physiotherapists who are specialists in Manual Therapy (MT) in the Reykjavik municipal area, and were fully convinced that the patients recruited were real patients. Physicians, who diagnosed these patients with WAD, had referred them to the specialists in MT for assessment and treatment. Only the patients, where the subjective complaints and the results from the physical examination and impairment tests made up a clear clinical picture of each patient's condition, were recruited into this study. To be included, the WAD group had to have had a history of symptoms from the head or neck after 1 or more MVCs for more than 6 months and pain intensity scoring ≥ 4 on a visual analog scale (VAS) during the last week. Individuals were excluded from the WAD group if their symptoms corresponded to grades I, III and IV, as classified by the Québec Task Force on WAD (Spitzer et al, 1995). Systemic diseases or prior psychiatric diagnosis of any kind excluded participation. All participants completed questionnaires recording demographic data and general health. The WAD group also completed the Whiplash Disability Questionnaire (WDQ) (Pinfold et al, 2004), the Tampa Scale for Kinesiophobia (Kori, Miller, and Todd, 1990) and graded their minimum and maximum pain on a VAS. All participants gave their informed consent. The National Bioethics Committee approved the study.

Measurements

Movement control of the cervical spine was recorded using a 3-Space Fastrak system (Polhemus, Colchester, VT) and the Fly Test, which is a custom-made software program (NeckCare Inc, Agoura Hills, CA). Figure 1 shows the experimental set-up.

Further detailed description of the experiment can be found in previously published papers by Kristjansson, Hardardottir, Asmundardottir, and Guðmundsson (2004) and Kristjansson and Oddsdottir (2010).

Two cursors, one blue and one black, were seen on a computer screen. The blue cursor (derived from the Fastrak system) indicated movements of the head–neck. The black cursor (derived from the Fly software program) traced the movement patterns represented by $x(t)$ and $y(t)$ in a coordinate system on the computer screen. Only the cursors were visible on the computer

Figure 1. The Fly Test. Experimental set-up. The placement of the two sensors was on the forehead and the back of the head. The participants were seated in front of a computer screen and were asked to find their neutral head posture facing forward. The distance from the participants' earlobe to the computer screen was 100 cm.

screen, not their trajectories, which made prediction of movements difficult. A software program was used to format and process the data for analysis. The participants were asked to use the blue cursor, derived from the sensors on the head, to follow as accurately as possible the black cursor of the Fly. The duration time was fixed, but the velocity of the Fly (target) varied between movement patterns, as did the path curvature within each pattern, so that the Fly moved faster on straight segments and slower in bends. Three different movement patterns of varying difficulty: (1) easy; (2) medium and (3) difficult were created for the test procedure (Figure 2).

The outcome measures were AA, ToT, and JI. AA was recorded by continuously calculating the absolute distance (radius) in millimeters between the two cursors during the test sequence. The criterion used was error magnitude (test accuracy). The absolute value (unsigned) was calculated in pixels and converted into millimeters by multiplying by 0.36 (1 pixel = 0.36 mm in this test). For ToT, an invisible free zone was created surrounding and moving with the target (the Fly). During a trial, the percentage of total time spent within the free zone was calculated and represented as ToT. The shape and size of the free zone was determined by plotting the coordinates (x, y) of 10 healthy individuals, and this determined a zone representing the difference between the actual points and the predefined points. By using vectors ($A_t(P_t - Q_t)$), a scatter plot was obtained which was distributed around the center of the coordinate system. The circle around the center was divided into 24 equally large sectors. Then, for each of the 24 sectors, quartiles were found and standard deviations (SDs) of the distance from the center were measured. The size of the free zone was set at 2 SDs from the center (Kristjansson and Oddsdottir, 2010). Jerk (i.e. smoothness of movement) was calculated and represented by an index normalized by the smoothness of the path of the Fly itself. This was performed by calculating the third derivative of the two-dimensional position data $x(t)$ and $y(t)$ and integrating the quadratic sum over time, using the equation based on the works of Teulings, Contreras-Vidal, Stelmach, and Adler (1997). The integral was evaluated for both the path that the Fly covered and the path created by the patient. The normalized jerk value (JI) was calculated using the relation:

$$\mathrm{JI} = \frac{\int \left[\left(\mathrm{d}^3 x_{\mathrm{p}} / \mathrm{d}t^3 \right)^2 + \left(\mathrm{d}^3 y_{\mathrm{p}} / \mathrm{d}t^3 \right)^2 \right] \mathrm{d}t}{\int \left[\left(\mathrm{d}^3 x_{\mathrm{FLY}} / \mathrm{d}t^3 \right)^2 + \left(\mathrm{d}^3 y_{\mathrm{FLY}} / \mathrm{d}t^3 \right)^2 \right] \mathrm{d}t}.$$

This ensured that geometrical and temporal features of various curves of the Fly did not influence the jerk value. Due to the unstable behavior of numerical differentiation, the $x(t)$ and $y(t)$ curves of both the path of the Fly and the path created by the subject were filtered using a fourth-order Butterworth low-pass filter with a cut-off frequency of 4 Hz. Second, the curves were interpolated using spline filter and resampled at 50 Hz, creating equal time steps between the points, making the numerical differentiation less susceptible to errors. The quadratic sums of the third derivative were calculated, and the highest 5% of the values were excluded to prevent bias due to numerical errors.

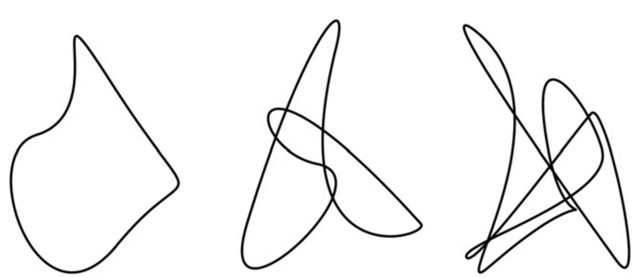

Figure 2. The movement patterns of the Fly. From left to right: Easy, medium, and difficult movement patterns traced by the Fly, which the participants were required to follow by moving their head and neck. The duration of the patterns was 25, 40 and 50 s, respectively.

Procedure

The participants were provided with information about the test procedure. Demographic data were recorded, and the WAD group completed the questionnaires. The intention and nature of the task required of the participants was explained (i.e. to use their neck movements to track as accurately as possible a moving Fly (the target) on the computer screen). To become familiarized with the task, the participants executed one movement pattern twice (a test pattern), and this pattern was not used for measurements. The participants were then required to repeat each of the three movement patterns three times, with a 10-s interval between each trial. The test was performed in random order across patterns and trials. The participants had no knowledge about the different difficulty grades of the patterns.

Two conditions were tested using the Fly Test: (1) sincere and (2) feigned efforts. In the former, the participants were instructed to use their head/neck movements to track the moving Fly as accurately as possible (sincere effort). In the latter, a short vignette was presented describing a fictitious accident (asymptomatic group) or imagining more intense pain/suffering (WAD group) (feigned effort), and the test was performed as affected by these more serious conditions. A break of 10 min between the two conditions was included. The protocol resembles the one used by Dvir, Prushansky, and Peretz (2001) and included reading two different paragraphs for the study groups. The following paragraph was read to the asymptomatic participants:

> Imagine that 1 year ago, you were involved in a MVC. As a result, you have suffered from various symptoms such as headache and neck pain. Today, although symptom free, you claim damages in your neck after this car collision. In the next set of measurements, try to convince me that your claim is well founded and that you still suffer from these symptoms.

The following paragraph was read to the WAD group:

> Imagine that you are suffering from pain which is much more intense than what you are actually experiencing now. Perform the test again as if under higher level of pain.

No instructions regarding the strategy or style of performance were given. The same protocol was then followed.

Data analysis

The absolute error in millimeters ± SD was used to indicate AA. ToT was indicated as the percentage of the total time used within the free zone during the trial. Finally, the normalized jerk (JI) was calculated. Means of three trials for each movement pattern were calculated for each subject for all dependent variables and used in the analysis. Analysis of variance (ANOVA) with repeated measures was used for comparison between the three independent variables: (1) patterns; (2) type of effort (sincere and feigned) and (3) groups. The model used to describe the data includes the main effects for the pattern and group. Age, gender and claim status were used as covariates in a two-way ANOVA with AA, ToT, and JI, each as a dependent variable, and type of effort as a between-subject factor. Discriminant analysis was undertaken to determine whether the WAD group's sincere and the asymptomatic group's feigned type of effort, on the one hand, and the WAD group's sincere and feigned effort, on the other hand, could be categorized on the basis of each of the three outcome measures. Stepwise discriminant analysis was used, with the type of effort as the two dependent variables and the score from the three outcome measures as the independent variables. The significance level for all tests was set at 0.05.

Pearson's correlation was used to ascertain the association between the test results versus the scores of VAS and the questionnaires. SPSS Version 18 (SPSS Inc., Chicago, IL) was used for statistical analysis.

Results

Subject characteristics, pain intensity and questionnaire scores are shown in Table 1. The scores of the questionnaires represent the self-report on the day the measurements took place. The VAS indicates maximum and minimum pain intensity during the past seven days. The claim status did not affect the WAD group's performances.

Sincere effort in the WAD group versus feigned effort in the asymptomatic group

Amplitude accuracy

The test results are demonstrated in Figure 3. The WAD group's sincere effort compared to the feigned effort of the asymptomatic group revealed significant differences ($F_{1,581} = 203.390$, $p < 0.01$). There was a significant effect for gender ($F_{1,581} = 10.704$, $p < 0.05$) but not for age. The gender-by-effort (type of effort) interaction was not significant ($F_{1,580} = 3.125$, $p = 0.078$). Furthermore, discriminant analysis resulted in correct categorization of 81.5% of the aforementioned groups' performances, sensitivity 87.3% (95% CI: 79.4–92.4) and specificity 75.3% (95% CI: 65.6–82.9). A cut-off score of 5.5 mm in AA could differentiate the feigned performance of the asymptomatic group from the WAD group's sincere effort, sensitivity 79.4% (95% CI: 63.2–89.7) and specificity 67.7% (95% CI: 50.1–81.4).

Table 1. Comparison of demographics and level of pain intensity and results of the questionnaires.

	WAD group ($n = 34$)	Asymptomatic group ($n = 31$)
Age* (years)	42.1 (8.7)	37.9 (16.7)
Gender (male/female)	6/28	15/16
VAS (max/min (0–10))	7.8/3.0	–
WDQ (0–130)	57.3 (30.5)	–
Tampa (17–68)	32 (6.2)	–
Claim status (closed/open)	25/9	–

WAD, whiplash-associated disorder; VAS, visual analog scale; WDQ, Whiplash Disability Questionnaire; Tampa, Tampa Scale for kinesiophobia.
*No significant between-group differences. Data, except for gender, VAS and claim status are expressed as mean (SD).

Time on target

The results are demonstrated in Figure 4. Significant differences between the sincere effort in the WAD group and the feigned effort in the asymptomatic group were revealed ($F_{1,581} = 127.932$, $p < 0.05$). There was no effect of age or gender or gender-by-effort interaction. The discriminant analysis resulted in correct categorization of 71.8% of the aforementioned groups' performances, sensitivity 63.7% (95% CI: 54.1–72.4) and specificity 80.6% (95% CI: 71.5–87.4). Furthermore, a score above 11.0% in ToT indicated correctly categorized whiplash patients, sensitivity 82.3% (95% CI: 66.5–91.7) and specificity 64.5% (95% CI: 46.9–78.9).

Jerk index

An overall value was obtained from the whole curve. Table 2 shows the mean JI values in both groups and both efforts. The jerk calculations did not reveal significant differences between the WAD and asymptomatic groups' sincere and feigned effort, respectively ($p = 0.9$). There was a significant effect for gender ($F_{1,581} = 11.817$, $p < 0.05$), but not for age. The gender-by-effort (type of effort) interaction was significant ($F_{1,580} = 25.112$, $p < 0.001$). Furthermore, only 53.3% of the aforementioned groups' performance resulted in correct categorization, sensitivity 62.7% (95% CI: 53.1–71.5) and specificity 43.0% (95% CI: 33.4–53.2). With a cut-off score set at 1.79 the sensitivity versus specificity was 82.4% (95% CI: 66.5–91.7) and 38.8% (95% CI: 23.7–56.2), respectively.

Sincere versus feigned effort in the WAD group

In the WAD group, all three measures: (1) AA; (2) ToT and (3) JI differed significantly between types of effort ($F_{2,1220} = 254.833$, $p < 0.01$), revealing poorer performances in the feigned effort. The discriminant analysis resulted in correctly categorizing 78.4% of the WAD group's effort types, by use of all three measures and patterns as predictor variables, sensitivity 79.4% (95% CI: 70.6–86.1) and specificity 77.5% (95% CI: 68.4–84.5).

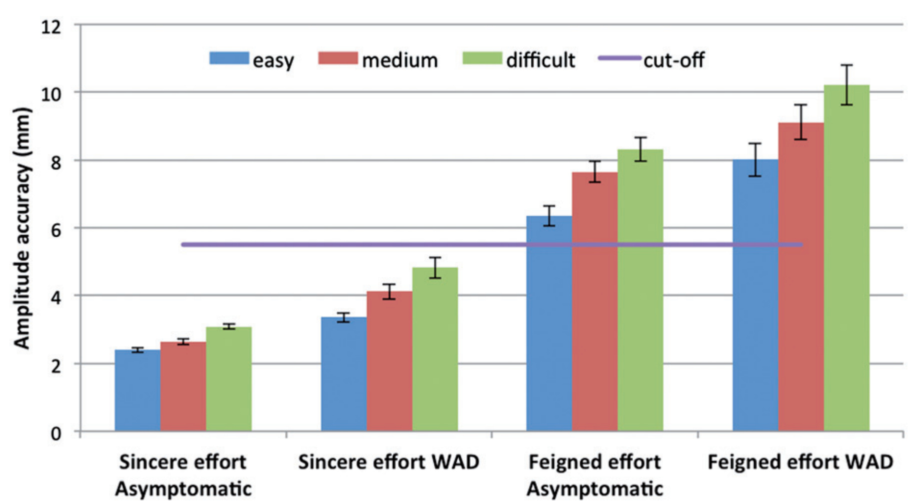

Figure 3. Amplitude accuracy (AA). Mean (SE). Significant differences between patterns and types of effort within both groups ($p < 0.01$). Significant between-group differences in both levels of effort ($p < 0.01$). No effect of age, or repetitions.

Weak or no correlation was found between the test results and the questionnaires in the WAD group. The correlation was significant between the test results on the one hand and the WDQ and pain intensity measured by VAS on the other hand (Table 3).

Discussion

The results of this study indicate that the Fly Test is capable of giving clinicians an indication when differentiating patients with non-specific neck–pain disorders or ''common whiplash'' (grade II) after MVCs from those who deliberately fake and/or exaggerate deficits of movement control in the cervical spine. The three outcome measures in the Fly Test reflect different aspects of proprioception, which is an underlying and complex feedback mechanism of movement control (Elliott, Helsen, and Chua, 2001; Gandevia and Burke, 1992; Gandevia, McCloskey, and Burke, 1992; Taylor and McCloskey, 1988; Woodworth, 1899) and therefore difficult to simulate. Real patients benefit from the fact that the movement patterns generated in the Fly Test are created within the scientific framework of motor control (Elliott, Helsen, and Chua, 2001; Lacquaniti, Terzuolo, and Viviani, 1983; Woodworth, 1899), showing their performances according to their actual movement control capacities (Kristjansson and Oddsdottir, 2010). The patterns generated by the Fly are following the same physiological rhythm as all normal movement patterns, synonymous with the grammar of conducting music (Rudolf, 1980).

The results of the AA and ToT measures in this study revealed that the groups' performances differed significantly in both types of effort and between efforts within each group as well as between the in-built difficulty levels of the movement patterns (Figures 3 and 4). These results are in accordance with our prior study (Kristjansson and Oddsdottir, 2010). Furthermore, AA and ToT were capable of differentiating between the performances of real patients with WAD (sincere effort) and the feigned performance of the asymptomatic group (feigned effort). The asymptomatic group spent significantly more time on target (40%) than did the WAD group (25%) in their sincere effort (Figure 4). All three parameters, including JI, were capable of differentiating genuine versus feigned performances in the WAD group. Both groups changed their strategy when asked to feign or exaggerate their performances. Scores of 5.5 mm and above in AA, 11.0% and below in ToT, and 1.79 and above in JI may be used by clinicians for screening patients with ''common whiplash'' who are suspected of feigning or exaggerating performances. Malingering or underperformance of patients' test behavior has been suggested when financial claims are involved (Schmand et al, 1998). Therefore, the precision and reproducibility of the measurements is critical when determining the severity of the patient's disorder. In the present study, the test results were calculated from nine repetitions in random order across patterns; the test results indicated consistency in performances as there was no effect of repetitions in AA, ToT and JI.

Smoothness (i.e. characterizing coordinated human movements) has been assessed in patients with neck pain of insidious and traumatic origin, by measuring movement jerk, indicating motor control disturbances (Feipel, Rondolet, LePallec, and DeWitte, 1999; Sjölander, Michaelson, Jaric, and Djupsjöbacka,

Table 2. Jerk index in each of the three movement patterns and in the two levels of effort, for the WAD and asymptomatic groups*.

Level of effort movement pattern	WAD group ($n = 34$)	Asymptomatic group ($n = 31$)
Sincere effort		
Easy†	1.78 (0.26)	1.69 (0.19)
Medium†	1.79 (0.23)	1.74 (0.15)
Difficult	1.48 (0.19)	1.49 (0.15)
Feigned effort		
Easy†	1.99 (0.59)	1.83 (0.35)
Medium	1.86 (0.35)	1.83 (0.30)
Difficult	1.54 (0.30)	1.50 (0.28)

WAD, whiplash-associated disorder.
*Data are mean (SD) normalized values. Significant differences were revealed between patterns within both groups ($p < 0.01$) and between types of effort within groups ($p < 0.01$).
†Significant between-group differences ($p < 0.05$).

Table 3. Correlation coefficient r for the relationship between the test results and the questionnaires for the WAD group.

	AA	ToT	JI
VAS max	0.31*	−0.31*	0.00
VAS min	0.46*	−0.47*	0.11
WDQ	0.44*	−0.42*	−0.01
TAMPA	−0.04	0.01	−0.09

AA, amplitude accuracy; ToT, time on target; JI, jerk index; VAS, visual analog scale for pain; WDQ, Whiplash Disability Questionnaire; TAMPA, Tampa Scale for Kinesiophobia.
*Significant correlation at the 0.01 levels.

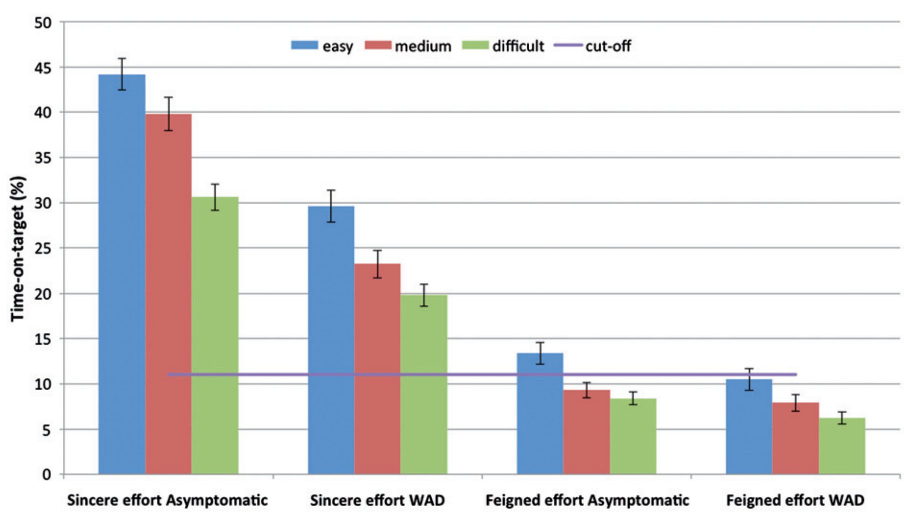

Figure 4. Time on target (ToT) (subvariable of directional accuracy (DA)). Mean (SE). Note: Higher percentage indicates better performance. Significant differences between patterns and types of effort within both groups ($p < 0.01$). Significant between-group difference in both levels of effort ($p < 0.01$). No effect of age, gender or repetitions.

Figure 5. Performances of a patient with severe disability after MVC. Two movement patterns in pink (smooth curves), and the patient's performances shown in blue (irregular curves, within the movement patterns). On the left the patient's shoulders are held still. On the right, the patient is allowed to support her head with the hands. During the Fly Test while the patient was allowed to support the head, her performance in AA was recorded as following: easy pattern = 5.77 mm (±4.74); medium = 5.85 mm (±4.75); difficult = 7.73 mm (±6.84).

2008). In the current study, the results of the jerk calculations showed that the JI can be used to discriminate the WAD group's two types of effort, showing significantly higher JI in the group's feigned efforts in all three movement patterns. This parameter may therefore be useful when patients exaggerate their performances. Although the JI did not show significant differences between the WAD group's sincere effort and the asymptomatic group's feigned effort, it may be a useful outcome measure in a clinical setting, as the between-group differences in the sincere type of effort were significant in the easy and medium patterns ($p < 0.05$) (Table 2). This is in accordance with another study, where slow- and medium-paced movements revealed significant group difference in genuine performances (Woodhouse, Stavdahl, and Vasseljen, 2010).

Although the outcome variables in our study appear to be valid indicators of whether the subjects are genuine whiplash patients, asymptomatic or faking/exaggerating performances, the main drawback is that no gold standard exists for feigning. In the absence of definitive proof that a person is feigning, a pattern including a wide range of values is needed that can truly classify 95% (preferably 99%) of any population at various ages and stages of different conditions and follow-up points in different settings. This could include: asymptomatic persons; subjects with no, mild, moderate or severe WAD; those reporting recovery; and within different medico-legal systems (no claim, care claim, disability claim) and claim statuses (soon after the MVCs, during the claim process, months after the claim is closed). No single test can detect fraudulent compensation claims, therefore, a collection of questionnaires and impairment tests including the Fly Test, with more sophisticated variables, are necessary in order to identify those individuals that are faking.

The main limitation of the present study is that the results cannot be transferred to persons with severe WAD. Some persons (e.g. with suspected but undetected upper cervical spine hypermobility) may not be able to perform the Fly Test because of the incremental difficulty levels of patterns that are generated in a random order by the software for each test session. For such a worst-case scenario (see illustrations in Figure 5 showing a 40-year-old female with a score of 84 on the Neck Disability Index), the Fly Test has to be modified, including only the easy pattern with different sizes and velocities of the Fly's trajectories. According to the results of the present study (scores >5.5 mm in AA), this patient would be suspected of faking her performances when she, in fact, is a real patient.

This shortcoming of the Fly Test became evident to some extent in the present study, as some of the patients with more severe WAD had problems in executing the difficult pattern in the Fly Test. The question remains, how can one expect this test to be of any use in clinical settings if severely injured patients score equally as those who fake? In a prospective study identifying distinctive trajectories for pain/disability and posttraumatic stress disorder, the effects of injury compensation claim lodgment on the trajectories was examined (Sterling, Hendrikz, and Kenardy, 2010). The study revealed that claim lodgment had no significant association with a more severe pain and disability trajectory. Therefore, patients with severe pain and disability are less likely to be faking. However, it can be reasoned that patients with no or mild symptoms will be more likely to feign their performances for secondary gains (Sterling, Hendrikz, and Kenardy, 2010). The inconsistency in the gender distribution of the study groups and that they were not age matched could also be considered as a limitation of the study, especially because of the significant gender effect in AA and JI, but more women were recruited in the study. As a consequence, it cannot be ruled out that this has had an impact on the results.

Fear-avoidance beliefs as measured by Tampa were not elevated in our study. In fact, although some subjects revealed more pain and disability, their Tampa scores remained lower and correlated poorly with their test results. Furthermore, no association was found between the Tampa and the sincere performances in the Fly Test. This is in accordance with our previous studies (Kristjansson and Oddsdottir, 2010; Oddsdottir and Kristjansson, 2012). Weak or no correlation has earlier been demonstrated between Tampa and other physical measures as well as self-reported neck pain and disability in WAD (Sterling, Kenardy, Jull, and Vicenzino, 2003; Sterling et al, 2003). These results contradict the assumption that patients with chronic WAD grade II are characterized by fear-avoidance beliefs alone (Nederhand et al, 2004; Nieto, Miro, and Huguet, 2009).

Conclusion

The Fly Test was used to differentiate patients with WAD from asymptomatic persons who deliberately fake symptoms and from patients exaggerating symptoms. The results can provide clinicians an indication when patients with ''common whiplash'' are feigning/exaggerating performances, since the outcome measures correctly categorized 71.8–81.5% of the subjects. As yet, the Fly Test cannot be used to detect fraudulent compensation claims.

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Declaration of interest

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