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The Gait Outcomes Assessment List (GOAL): validation of a new assessment of gait function for children with cerebral palsy

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FAQ	Functional Assessment Questionnaire
FMS	Functional Mobility Scale
GOAL	Gait Outcomes Assessment List
GPS	Gait Profile Score
ICF	International Classification of Functioning, Disability and Health
IGA	Instrumented gait analysis

AIM We investigated the validity of the Gait Outcomes Assessment List (GOAL), as an assessment of gait function in children with cerebral palsy (CP).

METHOD We studied a prospective cohort of 105 children with CP (Gross Motor Function Classification System [GMFCS] levels I–III; 65 males, 40 females; mean [SD] age 11y 11mo [3y 5mo], range 6–20y), who attended gait assessment over a 10-month period. Parents completed the GOAL, Functional Mobility Scale (FMS), and Functional Assessment Questionnaire (FAQ) during their child's gait evaluation. Ninety children completed instrumented gait analysis (IGA). Total GOAL and domain scores, Gait Profile Score (GPS), and Gait Variable Scores were calculated.

RESULTS The total GOAL discriminated between GMFCS levels (mean [SD] GMFCS I, 72.5 [12.7]; GMFCS II, 61.4 [13.0]; GMFCS III, 38.8 [10.6]; [$F_{2,97}$=42.4, p<0.001]). Moderate correlations were found between total GOAL and FMS (5m and 50m r=0.59; 500m r=0.66) and FAQ walking (r=0.77) and activities list (r=0.75, p<0.01). There was a moderate negative correlation between total GOAL and GPS (r=−0.59) and gait appearance domain and GPS (r=−0.52, p<0.01).

INTERPRETATION The GOAL is a valid assessment of gait function in ambulant children with CP. It has the potential to improve understanding of the child's and parents' priorities and thus, in conjunction with IGA, provide a more balanced assessment across the domains of the World Health Organization's International Classification of Functioning, Disability and Health.

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What this paper adds

- The Gait Outcomes Assessment List (GOAL) can discriminate between Gross Motor Function Classification System levels.
- The GOAL correlates with standard functional assessments and gait analysis.
- Used with gait analysis, the GOAL provides comprehensive assessment across all International Classification of Functioning, Disability and Health domains.

[Main text]

Approximately two-thirds of children with cerebral palsy (CP) are ambulant.[1] Musculoskeletal impairments affect many aspects of the child's physical functioning, limiting their levels of physical activity and participation.[2] Children with CP often undergo interventions designed to modify the natural history of musculoskeletal pathologies and improve their gross motor and gait function, including injections of botulinum neurotoxin A, physiotherapy, orthopaedic surgery, and neurosurgical treatment such as selective dorsal root rhizotomy.[2] It is extremely important to be able to accurately assess the outcomes of these interventions. Outcome assessments must consider a child's level of function across multiple domains.[3] The World Health Organization's International Classification of Functioning, Disability and Health (ICF)[4] provides a useful framework for the development of such assessments. The ICF considers health conditions in three domains: body structure and function, activities, and participation. These domains are influenced by environmental and personal factors.[4]

A meaningful outcome assessment for children with CP should capture the multidimensional nature of physical ability, consider the contextual factors that contribute to functioning, and reflect the aspirations and expectations of children and their parents.[5–7] Currently, gross motor and gait function in CP is assessed using a variety of outcome assessments.[5] Although these assessments provide a wealth of objective information about a child's motor function, they generate little information about the child's or parents' views of

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functioning, and do not attempt to understand their priorities or expectations. Currently no single outcome assessment includes all ICF domains.

To judge the effectiveness of any intervention in children with CP, it is important to understand the priorities and expectations of the child and parent. It is widely accepted that a family-centred approach to intervention improves motivation and outcomes.[7,8] Research has shown that in many cases intervention programmes for children with CP are not always aligned with the aspirations or expectations of the family.[9] If we can assess and understand family priorities and expectations, we may be able to align the aims of clinicians with those of families and improve outcomes of interventions for the child and satisfaction.[1]

The Gait Outcomes Assessment List (GOAL) is a new outcome assessment to evaluate gait priorities and functional mobility for ambulant children with CP. It was developed by a multidisciplinary team at The Hospital for Sick Children in Toronto, Canada.[10] The GOAL is the first outcome assessment to be developed by direct input from children with CP and their parents. Health care professionals were involved subsequently to provide their input. There are two versions of the questionnaire: parent and child. The GOAL assesses the child's performance using 48 items (in both versions) grouped into seven domains. The GOAL questionnaire, draft 4.3 parent version, was used in this study. The GOAL questionnaire and scoring details can be found in Appendices S1 and S2 (online supporting information).

The aim of this study is to investigate the validity of the GOAL as an assessment of gait function in ambulant children with CP.

The GOAL was introduced to the clinical assessment matrix of the Hugh Williamson Gait Analysis Laboratory in 2014. Construct validity was examined by assessing the ability of the GOAL to discriminate between levels of the Gross Motor Function Classification System (GMFCS).[11]

Concurrent validity was assessed comparing the GOAL with two related valid and reliable assessments of motor function, the Functional Activity Questionnaire (FAQ)[12,13] and the Functional Mobility Scale (FMS),[14–16] and the criterion standard for measuring gait function, instrumented gait analysis (IGA).

METHOD

This was a prospective cohort study.

Participants

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Inclusion criteria were children with a diagnosis of CP, classified in GMFCS[11] levels I to III, and registered on the Victorian Cerebral Palsy Register; aged 6 to 20 years; and who attended a gait analysis laboratory between March and December 2014. Children were excluded if their parent was unable, or declined, to complete the GOAL, including parents of a non-English speaking background who could not complete the GOAL without the assistance of an interpreter.

Measures

The GOAL questionnaire, FAQ, and FMS were completed as part of the Hugh Williamson Gait Analysis Laboratory clinical protocol following standardized procedures at the time of gait assessment. The study was approved by The Royal Children's Hospital Ethics Committee (HREC 34234A).

The FAQ is a 10-point scale of the typical level of a child's walking function in their community environment, with a further 22 items of gross motor skills. The walking scale is scored from 1 'cannot take any steps at all' to 10 'walks, runs and climbs on level and uneven terrain without difficulty or assistance'. Additional items that the child can do are noted. The FAQ is a measure of performance. The parent completes the rating of this scale.[12,13]

The FMS is a performance measure, classifying mobility on the basis of the use of mobility devices across three distances, 5m, 50m, and 500m, which represent home, school, and community distances. Assessment is by the clinician on the basis of questions asked of the parent or child. The mobility of the child is scored from 1 to 6 for each distance, with 1 representing use of a wheelchair and 6 representing independence on all surfaces.[14–16]

The GOAL questionnaire, draft 4.3 parent version, was used in this study. The GOAL was completed on paper by parents, with the questionnaires kept in the Hugh Williamson Gait Analysis Laboratory clinical records. Two researchers (AD, AT) entered GOAL item data into a formula-protected Microsoft Excel 2013 spreadsheet provided by the GOAL developers. Scoring of the GOAL was performed automatically by the inbuilt formula of the spreadsheet.

The GOAL consists of 48 items grouped into seven domains; domain A: activities of daily living and independence; domain B: gait function and mobility; domain C: pain, discomfort and fatigue; domain D: physical activities, sports and recreation; domain E: gait pattern and appearance; domain F: use of braces and mobility aids; domain G: body image and self-esteem.

Appendix S1 (online supporting information) details the GOAL scoring procedure and

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management of missing data. Scores are additive to provide the item score. Scores for each domain and for the total GOAL are standardized and range from 0 (worst) to 100 (best).

Standardized item, domain, and total GOAL scores were calculated for each child. The maximum total GOAL score is 100 and a higher GOAL score equates to higher function.

IGA is considered the criterion standard for the assessment of gait function.[17] The Gait Profile Score (GPS) is a single index measure that summarizes the overall deviation of kinematic data relative to typical gait data.[18] The GPS consists of nine key kinematic variables, known as the Gait Variable Scores, which can be presented as a movement analysis profile. The GPS can be used to monitor progress, and to evaluate the outcome of interventions.[19–21] It has been shown to be valid and reliable.[19–21] The GPS is measured in degrees: a higher GPS indicates greater deviation from typical gait.

IGA was performed using a 50-Hz ten-camera Vicon system (Oxford Metrics Group, Oxford, UK). Reflective markers were applied to landmarks using a standardized procedure.[17] Kinematic data were calculated using Plugin Gait (Oxford Metric Group, Oxford, UK). Kinematic data were captured during barefoot walking with or without the use of assistive devices, depending on the child's usual walking ability. Gait Variable Scores, GPS, ankle dorsiflexion at 20% of the gait cycle, and maximum knee extension during stance phase were calculated from the kinematic data. All data for this study were stored in a password-protected database at the Hugh Williamson Gait Analysis Laboratory.

Statistical analysis

Statistical analyses were performed using Stata 13 (StataCorp, College Station, TX, USA).

On face value, domain A (activities of daily living and independence), domain B (gait function and mobility), and domain D (physical activities, games and recreation) seem to relate most closely to gross motor function, so the GOAL and these domain scores were used for analysis. In addition, domain E (gait appearance) was used for comparison with kinematic data.

To assess the discriminant ability of the GOAL, comparisons of the mean total GOAL, domain B and domain D for each GMFCS level using one-way analyses of variance (ANOVAs), and post hoc Scheffe's test were conducted. Domain A scores displayed a positive skew and required non-parametric analysis using a Kruskal–Wallis *H* test.

To evaluate concurrent validity with assessments of motor function, total GOAL and domain scores were correlated with FAQ and FMS using Spearman's rank correlation.

Concurrent validity of the total GOAL as an assessment of gait function was assessed

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using Spearman's rank correlations and linear regression analyses comparing the total GOAL and domain scores with the GPS.

RESULTS

Data from 105 children (65 males, 40 females) were included. There were 27 children classified in GMFCS level I, 58 in level II, and 20 in level III. The mean (SD) age was 11 years 11 months (3y 5mo), with a range of 6 to 20 years. The GOAL was completed by the parents of all 105 children. However, missing items resulted in some domain and total GOAL scores not being able to be derived. Table I shows the summary statistics of the total GOAL and domain scores. Ninety children completed IGA; 15 had a video-based assessment of their gait and as such had no kinematic data for inclusion in that comparison.

The total GOAL exhibited a normal distribution. Domain A (activities of daily living and independence) and domain C (pain, discomfort, and fatigue) showed a positive skew. The other domains were normally distributed.

Discriminant validity

A one-way ANOVA found a significant difference between the total GOAL and domains B and D per GMFCS level (Fig. 1). A Scheffe's post hoc test revealed that the total GOAL and domain scores were significantly higher for GMFCS level I than levels II or III, and that the total GOAL was significantly higher for GMFCS level II than for level III. The difference between mean total GOAL and domain scores for GMFCS level I versus II was substantially less than the difference between GMFCS levels II and III (Table II). A Kruskal–Wallis *H* test determined that domain A differed significantly between GMFCS levels (χ^2=3.50, p<0.001).

Concurrent validity

Spearman's rank correlations revealed moderate to good positive relationships between the total GOAL and FAQ. Linear regressions established that the FAQ can predict the total GOAL. FAQ walking accounted for 56% of the explained variability in the total GOAL, and FAQ activities accounted for 54% of the explained variability in the total GOAL. Domain B had the strongest correlations with FAQ. Linear regression found that FAQ walking accounted for 64% of the explained variability in domain B, while FAQ activities accounted for 61% of the explained variability in domain B. Correlations and regression equations are displayed in Table III.

There were moderate positive correlations between the total GOAL and FMS for 5m,

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50m, and 500m, with 500m the strongest. Similar results were found for domains A, B, and D (Table III).

Of the 90 children who had an IGA, 85 total GOAL scores were generated with a mean (SD) of 62.2 (5.9; range 17.0–94.7). The total GOAL had a moderate to good negative correlation with the GPS (r=−0.66, p<0.01). Children who scored the highest total GOAL had the lowest GPS, and vice versa (Fig. 2). Domains B, D, and E exhibited similar correlations with the GPS as the GOAL (Table III).

DISCUSSION

Through the emphasis of the ICF model of the health condition,[4] the GOAL was developed to assess gait function for ambulant children with CP. It is the first assessment to incorporate the child's and parents' priorities and expectations with direct input from children with CP and their parents during its development.[10] The GOAL has the potential for being a more meaningful assessment to evaluate interventions used to improve gait and function. It identifies how difficult each item is and how important achieving the item is as a desired outcome. Although the importance does not contribute to the scoring of the GOAL, and as such was not evaluated in this study, identification of specific priorities and preferences may influence decision making about choice and timing of interventions to achieve these aspirations. Meaningful discussions with the child and parent can be initiated, giving the opportunity for education and planning to inform clinical decisions about management and to align clinical aims with those of the child and parent. The GOAL may be used not only to evaluate interventions but to ensure better engagement of the child and parent with improved outcomes for the child.[6]

A previous study demonstrated that the GOAL has excellent internal consistency, good reliability, and excellent face and content validity.[10] This study evaluated the validity of the parent's version of the GOAL as an assessment of gait and gross motor function for ambulant children with CP. Discriminant and concurrent validity of the GOAL was tested by comparison with criterion standard assessments used to evaluate gait function in children with CP. The total GOAL and domain scores were used for comparison.

An important finding of our study was that the total GOAL can discriminate between GMFCS levels I to III. There were significant differences in the scores between GMFCS level I versus II, and II versus III. Similar results were found for domains B (gait function and mobility) and D (physical activities, games and recreation). Significant differences between GMFCS levels were also found for domain A using non-parametric

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methods. For all comparisons, there was a smaller difference in the mean total scores between GMFCS levels I and II than between levels II and III. This result was to be expected, as the differences between GMFCS levels I and II are less well defined than between other levels. Substantial variability has been shown in the distribution of GMFCS levels I and II between population registries,[22] suggesting a degree of uncertainty.

The total GOAL was found to have moderate correlation with assessments of motor function, the FMS, and the FAQ. This suggests that the GOAL does assess a similar construct to these tools, and can be interpreted as a valid assessment of gait function. However, the spread of total GOAL scores across individual FMS and FAQ categories was quite substantial. The relatively few items in these two categorical assessments may explain this. The FMS has just six categories while the FAQ has ten on its walking scale and 22 on its activities scale. The total GOAL contains more items and uses a standardized score ranging from 0 to 100; therefore continuous scores are possible. It may be that within each FMS or FAQ category there is a broad range of gait function, which is only detected with a more comprehensive assessment such as the GOAL. The GOAL also assesses multiple facets of function, such as self-esteem and pain, which are not included in the FAQ and FMS and so may explain the moderate correlation. Domains B and D were also able to differentiate between varying levels of functional mobility within our cohort.

The FMS and the GOAL are designed to assess mobility; however, the GOAL was designed for ambulant children only whereas the FMS can be applied to the entire spectrum of children with CP and is not disease specific.[14,15] The clustering of high FMS scores in this study, compared with the normal distribution of total GOAL, may indicate that the two assessments are not mutually exclusive, and can provide different levels of information for the clinician. The GOAL allows clinicians to assess the child's ability to perform a range of activities over a range of environments. The additional items from the FAQ provide extra information; however, many of the activities listed are age-dependent.[15] For children who are too young to perform a task, the score for the activity is zero, equivalent to the child being unable to perform the activity because of functional limitations. One advantage of the GOAL is that its developers have taken this issue into consideration, offering the opportunity to score an item in domain D as 'not been performed within the last year'.

It was not expected that the correlations between the total GOAL and FAQ and the total GOAL and FMS would be perfect. However, similarity implies that these are complementary tools.

Comparison of the total GOAL with a measure of gait function, the GPS (level of

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body structure and function of the ICF), showed the strongest correlation. Similar results were found with domains B, D, and E. These were a negative relationship, which was expected as a higher total GOAL and a lower GPS indicate more typical gait function. Although the correlation obtained was only a moderate negative relationship, this result still provides support for the GOAL being a valid assessment of gait function in children with ambulant CP.

Domain E (gait appearance) showed moderate correlation with the GPS. This was an unexpected finding as we thought this would show the strongest relationship. Domain E contains the items that we considered a priori to be most closely related to gait parameters.

IGA data have been used as validation criteria because they are the criterion standard for assessment of gait function.[17] However, IGA has limitations including expense and limited availability. More fundamentally, kinematic data that measure structure and function may not reflect the child's and parents' priorities. Kinematic data generated give objective information about how the child walks and, with interpretation, can tell the impairments that affect the child's gait; however, they do not tell us the effect of the impairment with respect to how difficult or how important an issue this may be to the child and parent. The GOAL allows clinicians to better understand the child's and families' priorities and what they consider important. The GOAL will complement existing assessments and provide much more comprehensive assessment to guide management for ambulant children with CP.

Limitations

There are several considerations for the use of the GOAL that have been highlighted. This current study evaluates the discriminant and content validity of the GOAL as a tool for assessing gait function in ambulant children with CP. However, further studies will be required with larger cohorts, from multiple centres, to assess validity and reliability of the GOAL in different populations.

The developers of the GOAL have recently completed its validation with respect to item selection, face, content, and construct validity.[10] Further refinement of GOAL items included may be required. The use of Rasch analysis to remove redundant items or to weight items may improve the ease of completion and clinical usefulness of the GOAL. Longitudinal assessments over time would also be valuable to establish its stability and to determine whether GOAL scores follow the known trajectory and natural history of motor function in children with CP. Also, further quantitative and qualitative analysis of the 'importance' component of the GOAL is required.

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In this study, the parent version of the GOAL was used for analysis; further evaluation of the child version is required. It will be essential to study the differences in perspectives and priorities between children and their parents. Written feedback from parents was encouraged while they were completing the questionnaire. This feedback is discussed in Appendix S1.

Assessment of the GOAL's sensitivity and responsiveness after intervention is also important, as it should be able to detect clinically important changes after intervention such as physiotherapy, botulinum neurotoxin A injections, and orthopaedic surgery. Further studies to establish responsiveness and a 'minimal clinically important difference' for the GOAL are required.

CONCLUSION

This study establishes the preliminary validity of the GOAL in measuring the gait function of ambulant children with CP. Evidence was found for the discriminant validity of the GOAL, and correlations were demonstrated with standard assessments of gross motor function and gait. The GOAL provides meaningful information about a child's function across multiple dimensions, accounts for the environmental and personal factors that may contribute to function (see Appendix S2, online supporting information), and assesses the priorities and expectations of children and their parents.

The GOAL will allow clinicians to better understand the motor abilities, priorities, and expectations of ambulant children with CP and to improve decision making about appropriate interventions. The GOAL will be an invaluable addition to the assessment tools available for gait function in CP.

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SUPPLEMENTARY INFORMATION

The following additional materials may be found online:

Appendix S1: Additional information.

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Appendix S2: Gait Outcomes Assessment List parent version.

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Table I: Means (SD) for the Gait Outcomes Assessment List (GOAL) and domain scores

GOAL	Mean (SD)
GOAL score (*n*=100)	59.9 (16.9)
Domain A: activities of daily living and independence (*n*=99)	75.0 (21.7)
Domain B: gait function and mobility (*n*=100)	65.8 (20.9)

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Domain C: pain/discomfort/fatigue (*n*=92)	73.2 (20.9)
Domain D: physical activities, games and recreation (*n*=76)	43.1 (22.4)
Domain E: gait appearance (*n*=102)	46.3 (24.1)
Domain F: use of braces and assistive devices (*n*=87)	50.8 (27.7)
Domain G: body image and self-esteem (*n*=100)	47.4 (19.1)

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Table II: Comparisons of means of the Gait Outcome Assessment List (GOAL) and domain scores by Gross Motor Function Classification System (GMFCS) level

	Mean (SD)			ANOVA	Scheffe's test		
	GMFCS I	GMFCS II	GMFCS III	$F_{(df)}$	Comparison	Difference means	Standard error (95% CI)
GOAL	72.5 (12.7)	61.4 (13.0)	38.8 (10.6)	$F_{(2,97)}$=42.4[a]			
(*n*=100)					I–II	11.1[a]	2.96 (3.8–18.5)
					I–III	33.7[a]	3.69 (24.5–42.8)
					II–III	22.5[a]	3.28 (14.4–30.7)
Domain B	81.1 (13.6)	69.2 (14.5)	36.2 (12.0)	$F_{(2,97)}$=64.1[a]			
(*n*=100)					I–II	11.9[a]	3.27 (3.8–20.0)
					I–III	45.0[a]	4.08 (34.8–55.1)
					II–III	33.0[a]	3.63 (24.0–42.1)
Domain D	60.9 (18.2)	42.6 (19.7)	19.6 (8.7)	$F_{(2,73)}$=23.9[a]			
(*n*=76)					I–II	18.3[a]	4.75 (6.4–30.2)
					I–III	41.2[a]	5.97 (26.3–56.1)
					II–III	22.9[a]	5.34 (9.6–36.3)

[a]p<0.001. ANOVA, analysis of variance; CI, confidence interval.

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Table III: Correlation coefficients of the Gait Outcome Assessment List (GOAL) and domain scores with the Functional Assessment Questionnaire (FAQ), Functional Mobility Scale (FMS), and Gait Profile Score (GPS)

	GOAL	Domain A	Domain B	Domain D
FAQ walking	0.77[a]	0.77[a]	0.80[a]	0.68[a]
FAQ activities	0.75[a]	0.71[a]	0.78[a]	0.67[a]
FMS 5m	0.59[a]	0.57[a]	0.68[a]	0.45[a]
FMS 50m	0.59[a]	0.60[a]	0.68[a]	0.61[a]
FMS 500m	0.66[a]	0.60[a]	0.68[a]	0.65[a]
		Domain E		
GPS (barefoot) *n*=85	−0.59[a]	−0.52[a]	−0.54[a]	−0.58[a]

[a]Spearman's *r*, $p<0.01$.

Figure 1: Relationship of the Gait Outcomes Assessment List (GOAL) to Gross Motor Function Classification (GMFCS) levels I to III.

Figure 2: Relationship of the Gait Outcomes Assessment List (GOAL) to Gait Profile Score (GPS).

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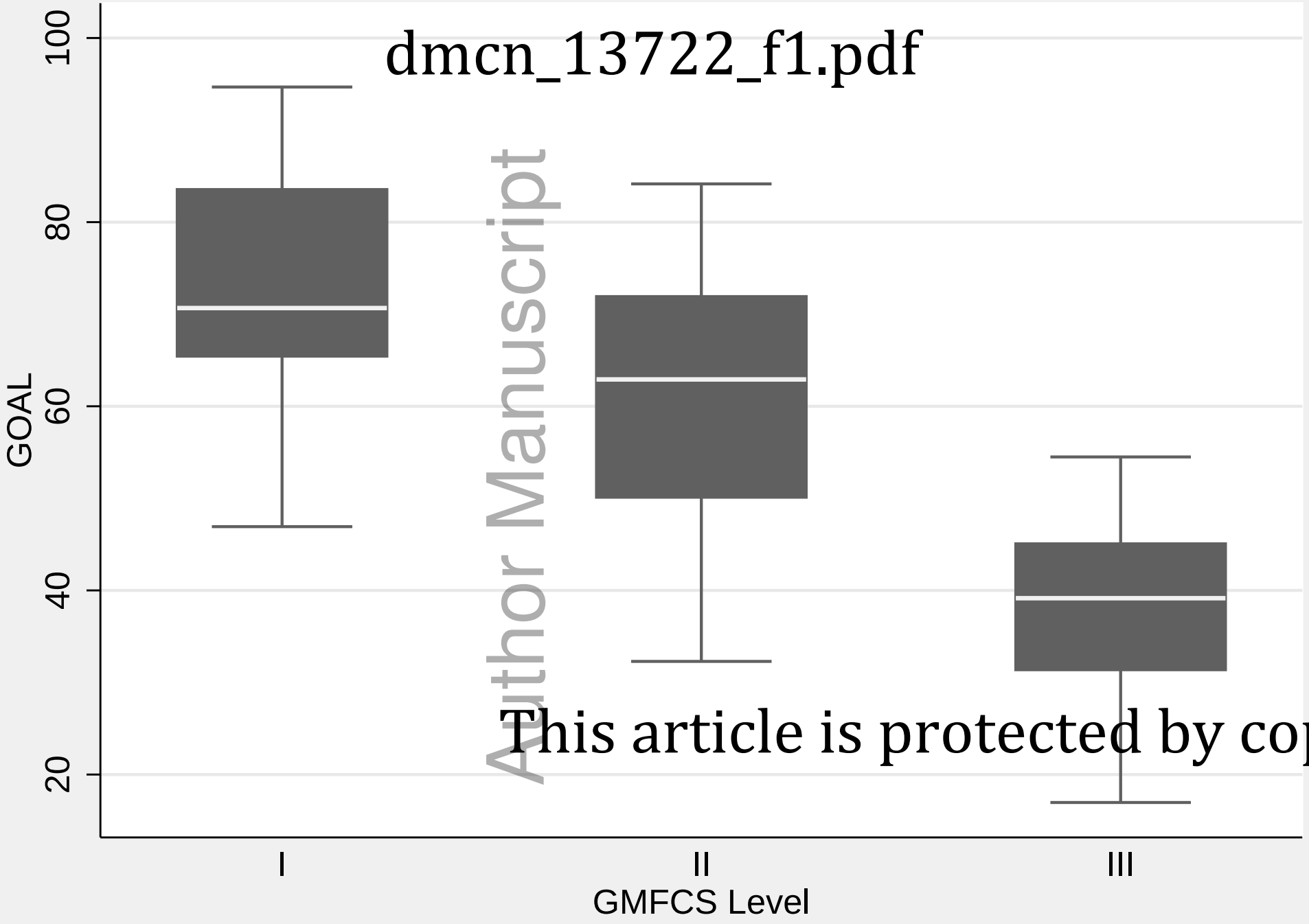

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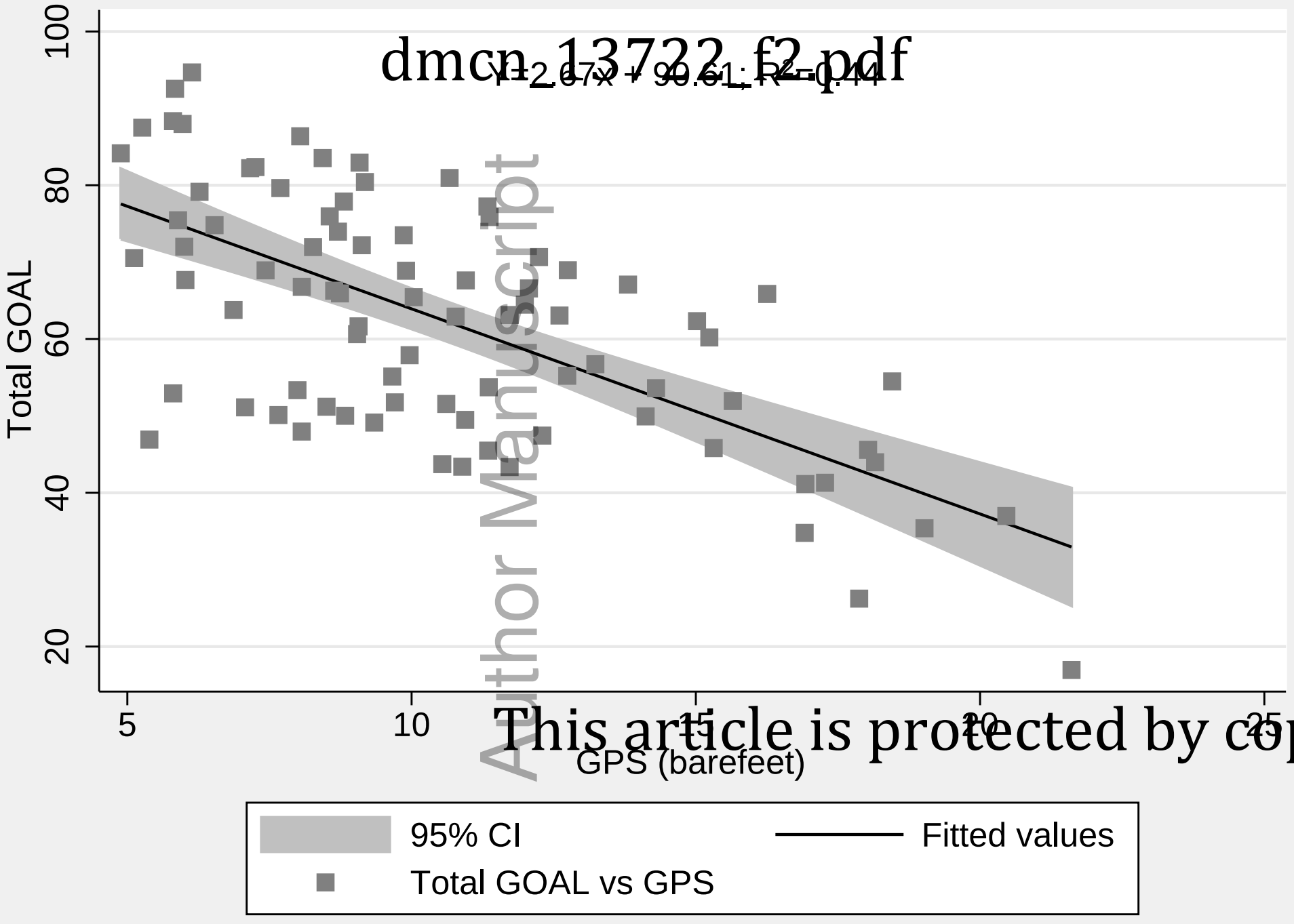

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