Title: Psychodiagnoses: Classification of the yips phenomenon based on musician’s dystonia

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ABSTRACT

Purpose: Similar to musician’s focal dystonia a task-specific phenomenon, known as yips has also been reported in professional athletes. Yips is usually described as focal dystonia, or choking under pressure, or as lying on a continuum between both. Based on the common occupational conditions across musicians and athletes, the present exploratory study aimed to investigate whether musicians diagnosed with focal dystonia and golfers affected with yips, can be similarly sub-classified based on their psychological profiles.

Methods: Twenty healthy musicians, 20 musicians with focal dystonia, 20 healthy golfers and 20 yips-affected golfers went through a test battery including three psycho-diagnostic standardized questionnaires (the Competitive Trait Anxiety Inventory, the Frost’s Multidimensional Perfectionism Scale, and the Stress Coping Questionnaire), measuring trait cognitive and somatic anxiety, perfectionistic tendencies and different stress coping strategies.

Results: Findings based on a clustering procedure suggest that similar to musician’s dystonia, yips-affected golfers can be classified into those with and those without specific elevated perfectionistic, stress and anxiety traits. The roles of these different psychological profiles as possible triggering factors of the yips are discussed and compared to those of musician’s dystonia.

Conclusion: The current study suggests that the yips phenomenon might cover a broader range of different subtypes of movement disturbances than those already suggested in the literature. Finally a theoretical model, which explains the role of the different triggering factors in the discrimination of the different subtypes, is suggested. A better classification and understanding of the different subtypes of yips could lead to a more accurate diagnosis and to the design of more individualized treatment intervention.
INTRODUCTION

Task-specific focal dystonias often affect individuals in professions where highly trained fine motor skills are required (1, for a review). Insights concerning the aetiology of task-specific focal dystonias have previously been obtained by comparing focal dystonia patients from different professions, for instance musicians and writers (2). Similarly, the current study attempts to examine and compare the psychological backgrounds of musicians diagnosed with focal dystonia and golfers affected with yips. Focal dystonia in musicians or musician’s dystonia is characterized by muscular incoordination and loss of voluntary motor control while playing a musical instrument. It usually affects one, two or more fingers of the more heavily used hand (3). As a result, irregularities in timing, unevenness in movements and slowing down of fast musical passages lead to a deterioration in the overall performance quality (3). Yips is a similar movement disorder and is defined as: “a psycho-neuromuscular impediment affecting the execution of fine motor skills during sporting performance” (4). In golfers it is mainly characterized by twisting or jerking of the lower arm (and wrist) either before or during ball contact. It mainly occurs in relatively short-distance putting and usually leads to missing the putt (4-6). Dystonic musicians (DM) and yips-affected golfers (YG) have involuntary movement and task-specificity in common. Task-specificity indicates that symptoms occur primarily while playing the musical instrument or while putting with the golf club. Furthermore, both occupations require an extensive amount of practicing and the execution of repetitive fine-motor temporospatially coordinated movements under high-pressure conditions (7).
Although there are commonalities between the two types of movement disorders, differences also exist. For instance, musician’s dystonia is characterized by a prolonged flexion or extension of the affected body part (finger[s]). In contrast, golfer’s yips is described more as a twisting or dystonic tremor-like movement. Furthermore, the prevalence of musician’s dystonia is estimated to be approximately 1% (3) and is much lower than the reported prevalence rates of yips, which range from 17 to 48 % (5,6,8). Finally, focal dystonia in musicians affects professional or experienced players (3). While yips-affected golfers also usually operate at a higher skill-level (9), a few recent studies have suggested the existence of yips symptoms in beginners (8,10,11,12).

The aetiology of both task-specific movement disorders is multifactorial and still not fully understood. Pathophysiological findings on focal dystonia have indicated abnormal inhibitory mechanisms, dysfunction of the sensorimotor system, abnormalities within the basal ganglia, and abnormal brain plasticity (1,3). Concerning the aetiology of golfer’s yips, different studies have classified this phenomenon either as focal dystonia (an organic problem), or ‘choking under pressure’ (a psychological problem), or on a continuum between both (6,9,13-15,16). Choking under pressure describes the occurrence of a significant drop in performance due to a perceived mismatch between situational demands and the athlete’s resources (e.g. due to increased performance anxiety) (17). Where on this continuum the yips phenomenon sits remains a matter of debate.

With respect to psychological investigations, findings in various forms of focal dystonia have clearly revealed that the condition in a considerable proportion of patients is related to psychological comorbidities. Review studies have concluded that those comorbidities were not a psychoreactive effect but pre-existed the dystonia onset (18). Concerning DM, studies
have found associations with higher levels of anxiety, perfectionism, neuroticism, social and/or other specific phobias (3,19). Recently, a more detailed investigation by Ioannou and Altenmüller (20) revealed that DM can be sub-classified into those with and those without psychological vulnerabilities, based mainly on contrasting levels of chronic perfectionism, anxiety and stress-coping styles. Further studies comparing the different subtypes have indicated that in addition to sensorimotor triggering factors (e.g. workload, handedness, instrument, controllability of actions etc.), psychological comorbidity should be considered as an additional triggering factor, which could significantly contribute to the manifestation of focal dystonia (21,22). However, increased levels of stress and anxieties related to music performance have been also reported in many healthy musicians, a condition known as music performance anxiety. Several studies have shown that musicians with performance anxiety often experience motor deterioration (23-25) or muscular stiffness, which could in turn disrupt fine motor coordination (26).

Studies focusing on yips’ psychological profiles remain highly contradictory (4). Some studies have found psychological features distinguishing between affected and unaffected athletes. For instance, yips-affected athletes would experience higher levels of perfectionism (27) and tend to consciously control their movements or to think obsessively about the problem (5). Furthermore Philippen and Lobinger (12) reported that about two thirds of YG primarily focus internally or on potential mistakes while stroking and Stinear et al. (16) reported alteration of the state anxiety between relaxed and stressed conditions, which was associated with changes in putting accuracy. In contrast, other studies could not confirm the existence of distinguishing psychological profiles (9,28) or any association with reinvestment (29) between yips-affected athletes and controls. The ambiguity may be due to different methodological approaches, such as the usage of different golfer’s yips criteria (28), or
because of a heterogeneity (e.g. different subtypes grouped together) among the yips-affected athletes (13). Only a few studies have suggested the existence of different subtypes of YG, for instance into those who primarily report movement-related symptoms versus those with anxiety-related symptoms (6,9,16) or those who may experiencing both symptom subtypes (4). There is therefore a necessity for further investigation of the psychological triggering factors to the manifestation of yips, and a clarification of the different possible subtypes.

The current open-design exploratory study aimed to investigate and compare the psychological profiles of DM and YG. Based on the nature of both occupations, which include high level of performance under stressful and demanding endo- and exogenous conditions, sub-characteristics related to trait anxiety, perfectionism and stress coping strategies were examined (20,28). The yips phenomenon, which remains under-investigated in comparison to focal dystonia, seems to cover a range of still-unidentified subtypes, as well as some already suggested in the literature. We expected that similar to DM (20,22), YG would be sub-classified into different psychological profiles. As a final goal we attempted to explain the role of those different psychological profiles by suggesting a broader classification of yips in comparison to previous evidence and reports. We hope that the comparison between the two similar movement disorders will provide further understanding of the yips phenomenon and its possible subtypes.

METHODS

Participants
Eighty participants, (20 healthy musicians [HM], 20 DM, 20 healthy golfers [HG] and 20 YG) filled out a psycho-diagnostic test battery. HM were randomly recruited via published announcements and were either freelancers or members of orchestras, music schools or
universities. DM were all diagnosed with focal hand dystonia by the last author (EA) and were selected from the outpatient clinic of Music Physiology and Musicians’ Medicine after setting exclusion criteria (i.e. participants with any neurological [e.g. secondary dystonia, tremor] or psychiatric [e.g. depression] disturbances). Patients selected in this way were contacted in random order and asked for their willingness to participate. Likewise, HG and YG were both randomly recruited from local golf clubs (also via published announcements) and from the database of the Institute of Psychology (same procedure as above). All golfers were re-tested and assigned as yips-affected and non-affected by the second author (MK). YG were mainly characterized by involuntary movements such as twisting or jerking of the lower arm during the one-handed putting test (28). Further characteristics can be seen in Table 1. All participants were informed of the requirements of the investigation and all provided informed consent before testing commenced. The protocol was conducted in accordance with the declaration of Helsinki and was approved by ethics committee of the board of the German Association of Psychology.

**Instruments**

The Competitive Trait Anxiety Inventory (CTAI) (GER: Wettkampf-Angst-Inventar Trait (30)), which is widely used in sport science, was used to assess trait anxiety before performance/competition. This psycho-diagnostic instrument has also been used in the past to assess competitive trait anxiety in musicians (20,22). CTAI assesses trait anxiety in three different components: “somatic anxiety” (e.g. “Before competition I feel nervous”), “self-doubt concern” (e.g. “Before competition I worry about failing under pressure”), and “concentration problems” (e.g. “Before competition I am prone to distractions”). All subscales consist of four items each and are answered on a 4-point scale ranging from 1 “not at all” to 4 “very much”. As suggested by the authors of the CTAI, the third subscale was
excluded from the analysis due to its low reliability (30). The reported Cronbach’s alpha value for the “somatic anxiety” subscale is .81 and for the “self-doubt concern” .83 (30).

Perfectionism was assessed with the German version of the Frost’s Multidimensional Perfectionism Scale (FMPS) (GER: Mehrdimensionale Perfektionismus Skala von Frost), (31). FMPS consists of 35 different items that form six different subscales: “concern over mistakes”, “personal standards”, “parental expectations”, “parental criticism”, “doubts about actions” and “organisation”. Cronbach’s alpha values for the six subscales range from .70 to .90. The participants had to rate each item on a 6-point scale from 1 “does not apply at all” to 6 “applies very well”.

Stress coping strategies were obtained via the short form of the German Stress Coping Questionnaire (SCQ) (GER: Stressverarbeitungsfragebogen), (32), which mainly examines positive and negative coping stress strategies. Positive coping strategies include the subscales “play down”, “guilt denial”, “distraction”, “substitutional satisfaction”, “situation control”, “reaction control” and “positive self-instruction”. Negative coping strategies include the subscales “flight tendency”, “mental perseveration”, “resignation” and “self-incrimination”. Finally two more neither positive nor negative strategies, “need for social support” and “active avoidance” are also included. The internal consistency (α) of the all the subscales ranges between .77 and .94. The participants had to imagine being in a stressful situation and estimate on a 5-point scale from 0 “not at all” to 4 “most likely” to which degree a statement applied to their own behaviour (total number of items 78). Finally, demographic, occupational and movement disorder information were also collected.

Statistical analysis
I. Group differences: A multivariate analysis (MANOVA) was used to examine possible
group differences (HM vs. DM vs. HG vs. YG) on the 21 different subscales which derive
from the three psycho-diagnostic questionnaires. An additional two-way MANOVA with
fixed factors of “occupation” (golfers vs. musicians) and “disorder” (affected vs. non-
affected) was also conducted in order to examine a possible interaction effect between the
two factors. Due to the fact that no group differences were found between the four groups
(apart from on two subscales) and no interaction effect was found between “occupation” and
“disorder” a more detailed data exploration was conducted.

II. Cluster analysis: Assuming that no group differences existed, all participants were grouped
together and all 19 subscales were used as dependent variables. A hierarchical procedure was
then applied in order to estimate the x number of clusters (33). Subsequently a K-means
analysis was performed in order to classify all participants into those x clusters. In order to
estimate which dependent variables (subscales) contributed the most to the classification of
participants into clusters, Mann-Whitney U tests were used. Finally the proportions, firstly
between all musicians (patients and controls) vs. all golfers (patients and controls) and
secondly between HM vs. DM vs. HG vs. YG, were calculated within each cluster, and tested
by a chi-square test for significant frequency differences.

Point-biserial correlations were used to estimate effects of age, years of experience and
cumulative hours of practicing, between clusters for musicians and golfers respectively. A
significance level of  p < .05 was used and Bonferroni corrections were applied in order to
prevent inflated type I error. Data analyses were performed in IBM SPSS Statistics software
package (version 24) and R (version 3.4.2).
RESULTS

Using Pillai’s trace on all 21 subscales indicated a marginally significant psychological group difference, $V = .993, F(63, 174) = 1.37, p = .058, \eta_p^2 = .331$. Follow-up univariate ANOVAs ($p$ accepted at < .05/21 subscales = .00238) were significant only for the subscales, “play down”: $F(3, 76) = 5.67, p = .001, \eta_p^2 = .183$, and “resignation”: $F(3, 76) = 5.45, p = .002, \eta_p^2 = .177$.

Bonferroni post-hoc tests revealed significant differences between DM vs. HG ($p = .001$) for the “play down” subscale, and between DM vs. HG ($p = .002$) and DM vs. YG ($p = .021$) for the “resignation” subscale (Table 2).

A two-way MANOVA with fixed factors “occupation” (golfers vs. musicians) and “disorder” (affected vs. non-affected) indicated only an effect for occupation, $V = .433, F(21, 56) = 2.04, p = .018, \eta_p^2 = .433$. Neither a disorder effect ($V = .323, F(21, 56) = 1.27, p > .05, \eta_p^2 = .233$) nor an interaction effect between the two factors ($V = .286, F(21, 56) = 1.07, p > .05, \eta_p^2 = .286$) were observed. Follow-up univariate ANOVAs ($p$ accepted at < .05/21 subscales = .00238) on the occupation effect were significant only for the “play down” subscale: $F(1, 76) = 10.97, p = .001, \eta_p^2 = .126$ with golfers showing a slightly higher score (1.9 ± 0.1 [M ± SE]) than musicians (1.4 ± 0.1 [M ± SE]).

Assuming that all four groups share similar psychological profiles due to a general lack of group differences, the 19 subscales without significant differences (excluding “play down” and “resignation” subscales) were used as single variables in the following clustering procedure. It was first established that none of the 19 variables (subscales) showed any substantial collinearity with any of the others: all correlations: -.31 ≤ $r$ ≤ .71 (Pearson).

Therefore all values were standardized into z-scores, since subscale evaluations were performed on different Likert scales. A hierarchical clustering analysis (Ward’s method -
Squared Euclidean distance) indicated the classification of all 80 participants into two distinct clusters (see Dendrogram, Supplemental Digital Content 1). Different clustering procedures, algorithms and distance measures revealed similar clustering patterns, indicating the stability of the results. Finally a K-means analysis, based on two clusters, classified all participants. Reliability, which was tested by a cross-tabulation percentage agreement between two randomly divided subsamples (split-half) of the original data, indicated a Rand index of .49, and an Adjusted Rand Index of .02 (34).

Due to unequal group sizes of the resulting clusters and the non-normally distributed data in some variables (Shapiro-Wilk < .05), a follow-up Mann-Whitney U tests between the two clusters indicated that 13 out of 20 variables (subscales) functioned as primary contributors to the classification of the participants into two clusters (p values were accepted after a Bonferroni correction at < .05/19_subscales = .0026). These characteristics were: “doubts about actions”, “concern over mistakes”, “flight tendency”, “parental criticism”, “parental expectations”, “active avoidance”, “mental perseveration”, “substitutional satisfaction”, “self-incrimination”, “personal standards”, “somatic anxiety”, “need for social support” and “self-doubt concern” (Figure 1). According to the classification of all participants into those two profiles, cluster 1 (representing participants with elevated scores of the above characteristics, n = 46) was labelled as “High tendency to Perfectionism, Anxiety and - inability to cope with - Stress” (HPAS) profile, and cluster 2 (representing participants with contrasting scores, n = 34) was labelled as “No tendency to Perfectionism, Anxiety and - inability to cope with - Stress” (NPAS) profile.

The association between the two clusters and the two occupations (musicians and golfers) revealed a significant difference: $\chi^2 (1) = 7.37, p = .007$ (also Fischer’s exact: $p = .012$).
Cluster 1 (HPAS) was mostly represented by musicians whereas cluster 2 (NPAS) was mostly represented by golfers. Finally, no significant association (2 x 4) was found between the two clusters and the proportion of HM, DM, HG and YG, \( \chi^2 (3) = 7.57, p > .05 \) (Table 3).

No differences between HPAS and NPAS clusters for DM and YG respectively were found concerning age, age when started playing, years and cumulative hours of experience, onset age, years of experience until onset, or level of expertise.

Due to differences in age, years of experience and cumulative hours of practicing between musicians and golfers, a point-biserial correlation was conducted in order to detect whether these three variables had any effect on the classification of musicians and golfers respectively to the two clusters (HPAS and NPAS). Results revealed that the classification of musicians into HPAS and NPAS was not significantly related to age, \( r_{pb} = .049, p > .05 \), years of experience, \( r_{pb} = .023, p > .05 \) or cumulative hours of practicing, \( r_{pb} = .088, p > .05 \). Hence, of the variability in the classification of musicians into two clusters, age accounted for \((R^2 = (.049)^2 = .0024)\) 0.2%, years of experience for 0.1% and cumulative hours of practicing for 1%. Likewise, the classification of golfers in HPAS and NPAS was not significantly related to age, \( r_{pb} = .269, p > .05 \), years of experience, \( r_{pb} = .142, p > .05 \) or cumulative hours of practicing, \( r_{pb} = -.080, p > .05 \). Age accounted for 7%, years of experience for 2%, and cumulative hours of practicing for 1% of the variability in the classification of golfers into clusters. Finally, in order to examine (indirect) whether any psychological trait (subscale) was a psycho-reactive effect (i.e. due to the onset of the motor disturbances) all subscales were correlated with the number of years after onset. Results indicated no significant correlations for DM whereas for the YG only one perfectionistic feature (“parental criticism”: \( r_s = .573, p = < .01 \)), one neutral (“active avoidance”: \( r_s = .638, p = < .01 \)) and two negative coping
styles, (“flight tendency”: \( r_s = .568, p = < .01 \); “resignation”: \( r_s = .584, p = < .01 \)) indicated significant correlations.

DISCUSSION

The current study revealed that all musicians and golfers (patients and healthy ones respectively) could be sub-classified into two different subgroups characterized by contrasting psychological profiles. The role of these different subtypes, as they relate to previously suggested triggering factors, are discussed and compared across yips and musician’s dystonia. Finally a more refined classification of the yips is suggested, which remains to be confirmed by further electrophysiological examinations.

Multiple comparisons between groups (HM vs. DM vs. HG vs. YG) revealed no psychological differences (20,28). Following studies suggesting that focal dystonia patients (18,20) and yips-affected athletes are characterized by psychological heterogeneity (4,6,16), a clustering analysis was conducted. Findings indeed indicated the existence of two contrasting psychological profiles. Classification of participants into those two profiles was based on either high levels (HPAS) or low levels (NPAS) of specific perfectionistic traits, negative coping stress strategies and somatic and cognitive trait anxieties (for specific characteristics see Figure 1). Distributions of the two occupations within the two clusters indicated that the HPAS profile was mostly represented by musicians (63%) whereas the NPAS profile was mostly represented by golfers (68%) (see Table 3). The higher representation of the HPAS profile by musicians compared to golfers can probably be explained by the fact that the majority of the former group were professionals. For professional musicians, performing is a livelihood activity, whereas for golfers of such a high handicap this is not the case (mean handicap < 27; handicap is a numerical representation of golfers’ playing ability with lower
numbers indicating better performance). However concerning the classification of each occupation individually into HPAS or NPAS, results indicated that proficiency (measured indirectly by “years of experience” and “cumulative hours or practicing”) did not play a role at all. Finally, the greater representation of musicians and golfers in the HPAS and NPAS profiles, respectively, did not differ across patients and controls. That is, whether a participant was a patient or control did not affect the probability of their having an HPAS or NPAS profile, and this was the case for musicians and golfers (see Table 3). This emphasizes the existence of two different psychological subtypes for both occupations.

Different subtypes in YG and DM have been also reported in the past. For instance, Ioannou and Altenmüller (20) found that one in two DM was characterized by psychological comorbidities. Likewise, different subtypes of YG have also been described by Smith et al. (6), who distinguished a group of YG with more dystonia-related symptoms (Type I) and a group with symptoms related to performance anxiety or choking (Type II). Both subtypes were further evaluated by Stinear et al. (16) while performing under low- and high-pressure conditions. Besides the fact that the cognitive anxiety of those classed as Type I was increased during the stress condition, putting performance remained unaffected. On the other hand, Type II golfers (with anxiety-related symptoms) demonstrated reduced putting accuracy under stress. The authors suggested that Type I could be more related to impaired initiation during motor execution, a characteristic related to patients suffering from focal hand dystonia. In contrast, Type II (anxiety-related symptoms) was suggested to be associated with performance anxiety rather than with motor impairments of the central nervous system (9,16). The authors further indicated that there are also YG who experience both physical (dystonic) and psychological (choking) symptoms, with these golfers being labelled as Type III (4). However this subtype remains under-investigated.
The study by Stinear et al. (16) which seems to be the only experimental investigation comparing these different subtypes may be partially problematic. No objective assessments were used for participants’ stress levels; instead the Competitive State Anxiety Inventory (CSAI-2) was used to evaluate state anxiety between low- and high-pressure conditions. This specific questionnaire has also been reported to have questionable validity and reliability (4,35). According to our knowledge there are no other experimental studies which investigated differences between the above suggested subtypes. An investigation similar to Stinear et al. (16) which compared the performance accuracy in DM under relax and stress conditions revealed no differences either for patients with or without psychological comorbidities (22). Moreover, and in contrast to Stinear et al. (16), the induced stress-level in DM was evaluated mainly by objective measurement (i.e. cortisol level and electrocardiography).

Apart from the limited evidence suggesting the classification of yips into Types I and II, the high prevalence of yips (17 to 48 %) seems to be at odds with that of musician’s dystonia (1%) and that of other forms of primary focal dystonia (< .05%) (36). Specifically, Smith et al., (34) suggested that of 72 YG (2 were excluded), 40 were assigned as Type I (dystonia symptoms), 16 as Type II (psychological symptoms) and 14 as Types I and II (or according to Clarke et al. (4) as Type III). Likewise, Stinear et al. (16), who used only 9 non-affected golfers and 15 yips-affected golfers, concluded that 8 yips-affected golfers could be classified as Type I, and 7 as Type II. Given that the prevalence of yips has been reported to range between 17 and 48% (hypothetical mean = 32.5%) (5,6,8), the proportions of YG classified as Type I (dystonia symptoms) in the two studies described above (57% in Smith et al., (6), 53% in Stinear et al., (16)) would suggest a hypothetical prevalence of Type I yips-affected
golfers of 17-18%. This remains high with respect to the prevalence of focal dystonia more generally, and we believe that yips may cover a broader range of different subtypes mostly unrelated to focal dystonia.

We argue that Type II YG (with anxiety-related symptoms), who showed motor instabilities under stress situations may not be related to those DM with psychological comorbidities. Instead, Type III golfers who experience both physical (dystonic) and psychological (choking) symptoms (4,6) maybe closer to those DM with additional psychological comorbidities (22). However, Type II YG seem to be linked to those “healthy” (non-dystonic) musicians who experience motor disturbances due to elevated performance anxiety (23-26,37). Up to 60 % of active musicians have reported a negative impact of music performance anxiety on their performance (24). Wesner et al. (25) reported that 21% of healthy musicians were characterized by increased levels of music performance anxiety; 16.5% of them reported that music performance anxiety also impairs their musical performance. Other studies have further indicated that the level of anxiety increases when musicians are performing with a higher public status (37), or when solo compared to ensemble performance is required (23). A parallel can be drawn between findings indicating performance deterioration in musicians who suffer from music performance anxiety with studies revealing yips-symptoms exacerbation under stressful situations (5,6,16). However more experimental studies investigating yips symptoms under stress and relax conditions are needed in order to clarify the effect of stress and anxiety on the motor performance of yips.

The extent of these psychological traits as aggravating risk factors for the triggering of task-specific symptoms in musician’s dystonia and yips remains poorly understood. A recent study which investigated a homogenous group of DM (only pianists) revealed that those
patients with elevated levels of anxiety, stress, and perfectionism had developed focal
dystonia about 10 to 15 years earlier than those patients without any psychological
comorbidity. It was suggested that those psychological behaviours (i.e. stress, anxiety and
perfectionism) in combination with other well-known sensorimotor triggering factors (see
next paragraph) could contribute as aggravating and accelerating risk factors to the
manifestation of focal dystonia (22). The pre-dystonic phase when minor and temporarily-
limited motor disturbances occur not only under stressful performance conditions but also,
for instance, while practicing, is known as *Dynamic Stereotype*, and is primarily linked to
musicians with elevated psychological traits, such as stress and perfectionism (14). A
prolongation of this situation which could lead to persistent dystonic movement patterns and
task-related loss of control, and therefore to focal dystonia (21). Therefore we suggest that
similar to DM, the HPAS-YG (yips-affected golfers with specific psychological tendencies)
may be described and further distinguished primarily into either (a) YG with performance
anxiety / choking (unrelated to dystonia), or to a lesser degree (b) YG with Dynamic
Stereotype (especially in cases where motor deterioration seems to also be present in non
stressful conditions), or to an even lesser degree (c) YG with focal dystonia accompanied by
psychological comorbidity.

The current study also detected a proportion of musicians and golfers who seem to have
developed their motor deficits in the absence of any stress, anxiety and perfectionism (i.e.
NPAS profile). Studies have already indicated that the deterioration of the fine motor control
of DM and YG, either with or without any psychological comorbidity, is mainly generated by
various common sensorimotor triggering factors. For instance, overuse (muscular fatigue),
demanding and intensive motor coordination, intensive repetitive patterns, gender (more
males are affected), handedness (right-handed players are mostly affected on the right hand
and left-handed players on the left), and specific biomechanics are among the most common triggering factors \( (3,6,9,10,13,16,21) \). Finally at least in musician’s dystonia a genetic predisposition has also been reported. About 35% of DM have family members affected by other forms of dystonia \( (38) \). Therefore, NPAS-YG (yips-affected golfers with no psychological tendencies), or those classified as Type I (dystonia symptoms) according to Stinear et al. \( (16) \), could form another subtype of yips. However the prevalence of this subtype (17-18%) remains highly at odds with the prevalence of those DM with no additional psychological comorbidities (0.5%) \( (17) \).

The prevalence inconsistency between the two movement disorders may be further explained by a few recent studies which identified yips symptoms in novices, especially during putting with one hand \( (8,10-12) \). These findings emphasize the postulation that not all subtypes of the yips should be linked either to task-specific focal dystonia or to psychological comorbidities (e.g. choking) or to a combination of both. Marquardt \( (10) \) suggested that yips in novices derives not from a general movement disturbance, but instead from disruption to the executive movement mechanism in a specific context. Finally, more recently Marquardt et al. \( (11) \), also studying yips symptoms in novices, suggested that the only motor abnormal behavior was jerking while putting. The authors therefore classified yips-affected athletes as falling under either “yips in golfers” or “jerking in novices”. Further studies are of course needed to clarify this classification but yips symptoms in amateurs highlight that further factors such as the level of expertise (e.g. handicap) and years of experience could also form crucial criteria for classifying yips-affected athletes \( (4,6) \). For instance, the high level of expertise (professional musicians) and the number of years of experience before onset (20-25 years) has been found to be associated with the manifestation of focal dystonia in musicians. Likewise, several studies drawing parallels between a subtype of YG and focal dystonia
included YG with a mean handicap below 7 and a mean of more than 25 years of experience (6,13).

Summarizing the above discussion we suggest that golfers with movement disturbances can be sub-classified to the following subgroups: a) to those with only “jerking symptoms in novices”, b) to those YG with “performance anxiety” (with psychological comorbidity mostly related to “choking under pressure”), c) to those YG with “dynamic stereotype” (with psychological comorbidity and more persistent motor disturbances), d) to those YG with “focal dystonia accompanied by psychological comorbidity”, and e) to those YG with “focal dystonia in the absence of any psychological comorbidity”. Although the suggested subtypes, and the extent to which they overlap or lie on a continuum, remain to be further investigated we suggest a schematic representation whereby the different subtypes can be diagnosed (or further explored) based on the different triggering factors (psychological and sensorimotor) which could initiate symptoms (Figure 2). The suggested subgroups, which aim to complement the initial classification suggested by Smith et al. (6), could be used for further exploration and explanation of the yips phenomenon in affected athletes.

The diagnostic parameters which could contribute significantly to a better distinction between the above suggested subtypes of yips are: i) psychological comorbidity, ii) level of expertise, dividing golfers into those with high (handicap < 5) and low (handicap > 20; (6), iii) years of experience before onset (<1 vs. 20-30), iv) family-related history, v) exploration of the sports biography / motor failure (e.g. whether motor symptoms occur under stressful, non-stressful, or both conditions (10)), and vi) evaluation based not only on subjective but also on objective measurements (e.g. kinematic screening test (8), physical / neurological phenomenological examination, test of sensory trick, muscular co-contractions etc.). The inclusion of all the
different subtypes under the label of yips could also explain the high yips-prevalence in contrast to musician’s dystonia (5,6,8). Our future plans focus on the evaluation and the (re)-
adjustment of the above-suggested subtypes of yips (and musician’s dystonia), using psychological, electrophysiological, and behavioral assessments. Investment in the classification of yips could enhance the diagnostic repertoire and promote studies focusing on more specific and tolerated treatments.

Finally we would like to underline a few limitations of the current investigation. First, the psycho-diagnostic evaluation was based on self-reports. A more reliable analysis should be preferably based on both subjective and objective measurements (9). Furthermore, musicians of the current study were mainly professional players (about two thirds) whereas the performance level of the recruited golfers was varied around the middle handicap range. Therefore, musicians and athletes of more similar professional levels should be examined. Additional characteristics such as cognitive patterns and the focus of attention, which have previously been suggested to be partly responsible for generating choking in at least a portion of yips-affected athletes, should also be examined (12,17,39). In addition, obsessive-compulsive behaviors, which have been highly detected in various forms of focal dystonia (18), remain to be comprehensively examined in both DM and YG. Finally, some investigations have suggested that psychological traits related to obsessional thinking and self-reported anxiety could be a psychoreactive phenomenon in YG (5,6,9). In contrast, perfectionism and trait anxiety investigated in the current study did not support any strong evidence of psycho-reaction, however more studies investigating a wider range of psychological aspects are needed to clarify this (18,20). Besides the challenges that motor and psychological behaviours may share common neurobiological networks (40), task-specific movement disorders remain rather unknown. Comparisons between similar
movement disorders may provide further insights, advancing understanding of the aetiological mechanisms behind them.

ACKNOWLEDGEMENTS

The current study is part of a larger project called “Focal Dystonia in Musicians and Athletes” conducted at the Institute of Music Physiology and Musicians’ Medicine at the Hannover University of Music, Drama and Media, and the Institute of Psychology, German Sport University Cologne. The authors also appreciate the insightful comments and discussion with each working group. The overall project is funded by the German Research Foundation (DFG) (AL 269/8-1; RA 940/12-1).

CONFLICT OF INTEREST

The authors declare that they have no relationships with companies or manufactures who will benefit from the results of the present study. The results of the present study do not constitute endorsement by ACSM and are presented clearly, honestly and without fabrication, falsification, or inappropriate data manipulation.

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**Supplemental digital content 1**: Dendrogram revised.tif

**Captions:**

**Figure 1.** Final cluster centers of the principal (left to right) subscales which contributed to the classification of participants into HPAS (n = 46) and NPAS (n = 34) profiles (clusters). Abbreviations: HPAS = High tendency to Perfectionism, Anxiety
and inability to cope with Stress profile; NPAS = No tendency to Perfectionism, Anxiety and inability to cope with Stress profile. Error bars: ±1SE.

Figure 2. The above schematic representation suggests the classification of the yips phenomenon inspired by the comparison between dystonic musicians and yips-affected golfers. The different boxes (subtypes) are located according to severity (y-axis) and experience (x-axis). Finally, the contribution of the psychological and/or sensorimotor triggering factors to the different subtypes is also indicated. Subtype (A) indicates mainly jerking symptoms in novice golf players. Subtype (B) indicates motor disturbances due to stressful and demanding conditions. Subtype (C) indicates subjects with subtle but more persistent motor disturbances. Those subjects are also characterized by more persistent psychological traits (e.g. elevated stress, anxiety, perfectionism etc.). Subtype (D) indicates an accelerated (earlier in years) manifestation of dystonic cramps. Usually these patients come from the Dynamic Stereotype phase. Finally, subtype (E) indicates those individuals with an already manifested focal dystonia. This subtype represents subjects who develop dystonia either exclusively due to sensorimotor triggering factors, or due to psychological and sensorimotor triggering factors (i.e. Dynamic Stereotype).

Subtypes (A) and (B) have so far been seen to be unrelated to focal dystonia. However, it remains unknown whether there is a continuum between these two subtypes and the absolute manifestation of dystonia.
Table 1. Participant characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HM</th>
<th>DM</th>
<th>HG</th>
<th>YG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: years (M ± SD)</td>
<td>39.7 ± 8.5</td>
<td>41.3 ± 8.5</td>
<td>51.3 ± 14.1</td>
<td>53.9 ± 13.9</td>
</tr>
<tr>
<td>Gender: (female / male) (n)</td>
<td>3 / 17</td>
<td>3 / 17</td>
<td>2 / 18</td>
<td>2 / 18</td>
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<tr>
<td>Handicap: (M ± SD)</td>
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<tr>
<td>Occupation: Professional / semi-professional</td>
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<td>or music student / amateur: (n)</td>
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<tr>
<td>Handedness: (right / left / both) (n)</td>
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<tr>
<td>Affected hand: (right / left / both) (n)</td>
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<tr>
<td>Started playing at the age of: (M ± SD)</td>
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<td>Years of experience: (M ± SD)</td>
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<td>Cumulative hs of experience: (M ± SD)</td>
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<td>Onset age of symptoms: (M ± SD)</td>
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<td>Years after onset: (M ± SD)</td>
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Abbreviations: M ± SD = mean ± standard deviation; HM = healthy musicians; DM = dystonic musicians; HG = healthy golfers; YG = yips-affected golfers. Instrument distribution for HM: piano 50%, violin 15%, violoncello 15%, flute 10%, clarinet 5% and horn 5%, (100% classical musicians) and for DM: piano 65%, guitar 20%, violin 5%, e-bass 5% and percussion 5% (75% classical musicians, 20% jazz / rock / pop and 5% other), DM vs. YG: *p = 210, z = -5.415, p < .001, **p = 190, z = -5.346, p < .001.

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Table 3. (HAPAS vs. NPAS) * Groups (Musicians vs. Golfers or HM vs. DM vs. HG vs. YG). Corroborations: 2x2 and 2x4

<table>
<thead>
<tr>
<th>Clusters</th>
<th>HM (15)</th>
<th>DM (14)</th>
<th>HG (8)</th>
<th>YG (9)</th>
<th>HM (5)</th>
<th>DM (6)</th>
<th>HG (12)</th>
<th>YG (11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupations (n)</td>
<td>63.04</td>
<td>36.95</td>
<td>32.35</td>
<td>67.64</td>
<td>72.50</td>
<td>42.50</td>
<td>27.50</td>
<td>57.50</td>
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<tr>
<td>Groups (n)</td>
<td>75.00</td>
<td>70.00</td>
<td>40.00</td>
<td>45.00</td>
<td>25.00</td>
<td>30.00</td>
<td>60.00</td>
<td>55.00</td>
</tr>
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Abbreviations: HM = healthy musicians; DM = dystonic musicians; HG = healthy golfers; YG = yips-affected golfers; HAPAS = High tendency to Perfectionism, Anxiety and - inability to cope with - Stress profile; NPAS = No tendency to Perfectionism, Anxiety and - inability to cope with Stress profile; * = significant; as = non-significant.
Classification of yips-affected golfers

Severity

A: Jerking (novices)
B: Performance Anxiety (Choking under Pressure)
C: Dynamic Stereotype
D: Dystonic Cramps
E: Focal Dystonia

Experience

Final Cluster Centers

$p < 0.0026, r = .6$ to $.3$

$p > .05, r = .3$ to $.0$

Cluster 1 (HPAS)
Cluster 2 (NPAS)